Aeronautical Engineering REVIEW

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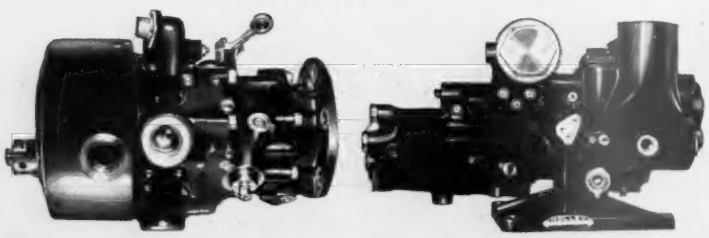
v.13 no.1

JANUARY, 1954

Within Seconds After Warning . . .

the Lockheed Starfire is in the air and on its way to altitudes of more than 45,000 feet. Holley designed and manufactured the turbine fuel control and the afterburner fuel control used on the F-94C's Pratt & Whitney Aircraft J-48 Jet Engine.



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Aeronautical Engineering Review

Vol. 13 — No. 1 JANUARY, 1954

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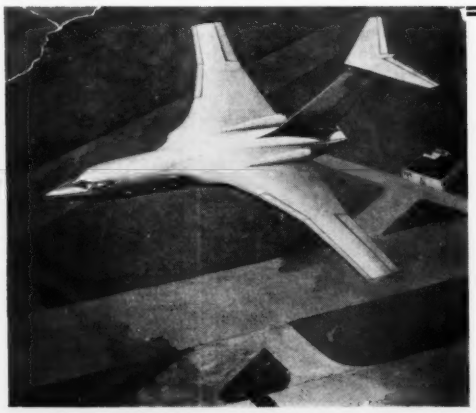

Cover—Artist's conception of the proposed M-186 commercial turbojet transport, developed by the Fairchild Aircraft Division of Fairchild Engine and Airplane Corporation. Plans for this new transport were recently announced to the aeronautical industry. For further details concerning the M-186, please refer to the Fairchild item on page 23.

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***Western Office:* 7660 Beverly Blvd., Los Angeles 36, Calif.**

Engineers mount cameras and X-wing on supersonic rocket to test new design.

On California desert, rocket begins flight reaching 3 times the speed of sound.

Desert craters fade away as camera records speed effect on new experimental wing.

Here, another wing de flaps violently from the p sure of the supersonic sp

Lockheed Scientists Shape the Forms o

Lockheed's Expanding Science Center Improves Today's Planes and Develops New Designs f

FIRST IN THE NATION'S ALL-WEATHER DEFENSE. Lockheed F-94 Starfires are jet interceptors loaded with electronics for almost automat flight. Starfires protect vital U. S. cities, even in darkness or bad weather. For 8 years, Lockheed has built more jets than any other manufacture

I.A.S. News Notes

January 1954

JET TRANSPORT MEETING PLANNED FOR SEATTLE, AUGUST 9-11

A National Meeting on "Turbine Powered Air Transportation" is being scheduled for early Fall in cooperation with the IAS Seattle Section, Arrangements Comm. Chairman G. W. Taylor, and the Boeing Airplane Company. The tentative 3-day program calls for technical sessions covering Aerodynamic Problems in Turbine Powered Transports, General Design and Manufacturing Problems, Operation of Turbine Powered Aircraft, Turbine Power Plants and Fuels, and Structural Problems in Jet Transports.

Papers for this meeting are now being invited. Abstracts of proposed papers should be submitted to IAS Headquarters in New York by FEBRUARY 15. Details of the meeting and program will be announced later in the Review.

* * * * * * * *

SUMMER MEETING PROGRAM CHANGES -- DATES JUNE 21-24

The Annual Summer Meeting in Los Angeles, June 21-24, will feature the following technical sessions: Accessory Design Problems; Electronics and Aircraft Electrical Systems; Military Aircraft and Weapons Operation; Mechanical Problems of Flight; Human Problems of Flight; Design Implications of Production Engineering and Tooling; Aerodynamics; and Structures.

Abstracts of proposed papers must be submitted by FEBRUARY 1 to R. G. Fuller, IAS, 7660 Beverly Boulevard, Los Angeles 36, California.

* * * * * * * *

NECROLOGY

Daniel W. Drake, MIAS, Group Engineer, Structures Test Group, Georgia Division, Lockheed Aircraft, on November 30

James W. Adams, MIAS, Consultant, New York and Mineola, on December 15.

* * * * * * * *

NATIONAL MEETINGS CALENDAR

Jan. 25-29	Twenty-Second Annual Meeting and Honors Night Dinner, Hotel Astor, New York
March 12	Flight Propulsion Meeting, Hotel Carter, Cleveland. (Restricted)
June 21-24	Annual Summer Meeting, IAS Building, 7660 Beverly Boulevard, Los Angeles, California
Aug. 9-11	Turbine Powered Air Transportation Meeting, Seattle, Washington

* * * * * * * *

I.A.S. News Notes (con't.)

NEW IAS CORPORATE MEMBER

Longren Aircraft Company, 2576 West Carson Street, Torrance, Calif.

* * * * * * * * * * *

CALENDAR OF SECTION MEETINGS

Jan. 11--Washington Section: Premeeting social and dinner, Hotel Burlington, 6:00 p.m. Meeting, Museum of Natural History Auditorium, 8:00 p.m. "Project Tinkertoy," by Harold B. Parker, USN BuAer. Also film, "We Saw It Happen." Trevor Gardner, Spec. Asst. for Devlp. to the Sec'y. of the Air Force, presiding. Joint meeting with SAE Washington Section.

Jan. 12--San Diego Section: IAS Building, Technical meeting, 7:30 p.m. "Aircraft Flutter" by M. Dublin, Chief of Dynamics, Consolidated Vultee Aircraft Corporation.

Jan. 13--St. Louis Section: Melbourne Hotel. Meeting, 6:30 p.m. "Flight Safety" by G. Merritt Preston, Chief, Flight Research Branch, Lewis Flight Propulsion Laboratory, NACA.

Jan. 14--Los Angeles Section: IAS Building. Specialist Meeting, 7:30 p.m. "Effect of Aircraft Jet Exhaust Impinging on Airfield Surfaces" by Norman L. Fox, Douglas Aircraft Company, Inc.

Jan. 18--Detroit Section: Small Auditorium, Engineering Society of Detroit. 8:00 p.m. Panel discussion on "The Business Airplane" with W. Piper, Sr., Piper Aircraft Corp.; T. R. Smith, Aero Design and Engr. Co.; E. T. Peabody, General Motors Corp.; and Jerry Francis, Charter Operator and Beech Distributor. Joint meeting with Aero Club of Michigan.

Jan. 18--Hagerstown Section: Packet Room, Terrace Restaurant. Meeting, 8:00 p.m. Program to consist of 1 1/2 hours of films on varied aeronautical subjects.

Jan. 21--Dayton Section: Location not known at press time. Reception, 6:30 p.m.; Dinner, 7:00 p.m.; Meeting, 8:00 p.m. United Aircraft Corporation's film, "We Saw It Happen," to be shown.

Jan. 21--Los Angeles Section: IAS Building. Social hour, 6:00 p.m.; Dinner, 7:00 p.m.; and Meeting 8:15 p.m. "Structures for High-Speed Aircraft," by Hall L. Hibbard and Jerome F. McBrearty.

Jan. 21--Texas Section: Ft. Worth International Airport. 8:00 p.m. "Flight Testing Military Aircraft," speaker unknown at press time.

Jan. 28--Texas Section: Arlington State College Auditorium, Arlington, Texas. Specialist Meeting, 8:00 p.m. "Metal Bonding Problems" by C. Carpenter, Group Engineer, Bell Aircraft Corporation.

Feb. 4--St. Louis Section: Location and time unknown at press time. "Rockets and Space Travel" by Wernher von Braun, Chief, Army Guided Missiles Laboratory.

* * * * * * * * * * *

IAS News

A Record of People and Events of Interest to Institute Members

Fourth International Aeronautical Conference

Photo Courtesy *The Aeroplane*

A. M. Ballantyne, RAeS Secy.; C. J. McCarthy, IAS Pres., and Sir William Farren, Pres. of the RAeS.

SEPTEMBER, LONDON, and the fourth joint IAS-RAeS aeronautical conference now seem but a pleasant memory from a distant past. However, the accompanying pictures and final reports, recently received from our friends on the other side of the Atlantic, are timely because they serve a dual purpose.

June, 1955, has been set as the target date for the next international aeronautical conference. This will be held in the U.S.A.—probably on the West Coast, if present plans materialize. In any event, every effort will be made by the Institute's Council and staff to make this affair a big success.

Our British contemporaries set some high standards in arranging and conducting the recent conference in London. The highlights of their program, as recorded here, should therefore serve as a guide to the future, as well as provide some pleasant memoirs of the past.

Prelude to the Fourth Conference

The week of September 7 was devoted to visits to the Farnborough Show and the various aircraft plants and to informal get-togethers. The Royal Aeronautical Society's building at 4 Hamilton Place served as a continuous open house, tourist bureau, and travelers' aid center for nearly 700 delegates for the entire week. It is a tribute to the cooperation and patience of the RAeS staff that not one of the 150 American delegates was found sleeping in Hyde Park or wandering the streets of Soho looking for University College.

Upon checking in at Hamilton Place, each delegate was provided with a complete kit of Conference materials and papers, as well as informative literature and maps of London and vicinity. All of this was neatly packaged in individually tagged brief cases generously supplied by the Shell-Mex Oil Company.

Honorary membership in the Royal Aero Club and in the Royal Automobile Club were additional courtesies extended to each American for the duration of the meetings.

American delegates and hosts at Vickers-Armstrongs, Ltd., prior to taking a flight in the Vickers Viscount.

(Left) IAS Director S. Paul Johnston and President C. J. McCarthy share the platform with RAeS President Sir William Farren as the latter formally opens the technical sessions at Friends Meeting House on September 15 **(Center photo)**.

(Bottom photos) Small groups of American and British delegates, earnestly discussing problems and ideas of mutual interest, were much in evidence throughout all plant visits.

Photo Left, Courtesy *Flight*
Photo Below, Courtesy *The Aeroplane*

Tuesday and Wednesday of the first week were devoted to the S.B.A.C. Show at Farnborough. Many of the delegates took full advantage of the courtesy extended by the S.B.A.C. and visited the Show on both days. Buses, provided by The Royal Aeronautical Society for all plant tours, were also on tap at the headquarters building for the trips to Farnborough.

So much has already been written and said about the S.B.A.C. exhibition that it is necessary here to add only our own commendations. As usual, the show made a favorable impression on visitors from the States.

Plant Tours

Visits to the Rolls-Royce plant at Derby and to the Vickers-Armstrong installations in the Weybridge area were scheduled for Thursday and Friday of the first week. Handley-Page entertained a group on Monday, September 14, at his plant in Cricklewood, while Bristol and Saunders-Roe divided the honors between them on Friday, September 18.

The outstanding highlight of the Vickers tour came when the group was treated to a flight in the new Vickers Viscount turbojet transport. The passenger visibility from this airplane, its performance, and flight characteristics elicited many favorable comments and discussions.

Formal Opening Session

University College, in West Central London, had been chosen originally as the site for the technical meetings. When it became apparent that the size of the participating audience

(Above) The Dinner-Dance at the Hotel Dorchester, September 17, brings the Fourth International Aeronautical Conference to a formal close. Guests were greeted here by *(right)* Sir William and Miss Mary Farren and Mrs. and Mr. C. J. McCarthy.

would overcrowd the College's largest lecture room, arrangements were made for the use of the Large Hall of Friends Meeting House on Euston Road. Its proximity to the College, where daily luncheons were held, and its adequate auditoriums and facilities made it a convenient location for meetings of this type.

Sir William Farren, 1953 President of The Royal Aeronautical Society, officially opened the Fourth International Aeronautical Conference at 9:30 a.m. on Tuesday, September 15. Professor B. J. Lloyd-Evans, representing the Provost of University College, welcomed the delegates to the College and expressed regrets that their own auditorium, destroyed during the war, had not yet been rebuilt.

A message from Her Majesty the Queen, wishing every success for the joint deliberations of the two societies, was presented by Sir William. Messages of a similar nature, expressing good wishes from the President of the United States, Dwight D. Eisenhower; Secretary of the USAF, Harold E. Talbott; and U. S. Navy Secretary R. B. Anderson, were also received. These were read by IAS President Charles J. McCarthy, who extended the thanks of the American delegates for the hospitality and many courtesies that had been shown them in connection with the Conference.

During his speech of welcome, Sir William Farren set the tenor of the technical sessions by allotting $1^1/_2$ hours for the presentation of each paper. He expressed the wish, however, that the speakers would actually use but $^1/_2$ hour for the formal presentations; thereby allowing a full hour for discussions—which, to him, were the "life-blood" of a conference. He also concurred with Mr. McCarthy's earlier expressed opinion that it wasn't necessary for discussers to spend half the allotted time telling the speaker what a great man he was and how much they liked him.

Technical Sessions

On this note, the meetings were opened at 11:30 a.m. in the Large Hall by presentation of the first paper.

It had been agreed by the Councils of the two societies that only twelve papers—six British and six American—should be presented at this year's Conference. Accordingly, these were split up over the 3-day period. Simultaneous sessions involving two auditoriums in Friends Meeting House, were carried out on the last two days of the meetings.

IAS President C. J. McCarthy discusses some interesting points with George R. Edwards, Manager and Chief Engineer of Vickers-Armstrongs, Weybridge.

All but three of the twelve papers had been submitted far enough in advance to allow the making of preprints before the Conference. These were bound together in a loose-leaf, formal cover and were presented to each delegate upon arrival in London.

Availability of advance papers enlivened the discussions immeasurably. Although participation in the discussions by American delegates showed marked improvement over that displayed at previous Conferences, it must be admitted that our British counterparts still excelled in this department.

All discussions and papers are presently being prepared for inclusion in the final volume of *Proceedings*. These missing parts will be supplied to delegates sometime in the early part of this year. Copies of the complete *Proceedings* may then be purchased by others directly from The Royal Aeronautical Society.

The twelve papers presented are as follows:

Structures for High Speed Aircraft—H. L. Hibbard and J. F. McBrearty, Vice-President—Engineering, and Chief Structures Engineer, respectively, Lockheed Aircraft Corporation.

Pod Mountings of Jet Engines—George S. Schairer, Chief of Technical Staff, Boeing Airplane Company.

Power Plants for Rotary-Wing Aircraft—A. Graham Forsyth, Chief Helicopter Engineer, Fairey Aviation Company, Ltd.

Structural Adhesives for Metal Aircraft—N. A. de Bruyne, Managing Director, Aero Research Ltd.

The Control of Flight—P. R. Bassett, President, Sperry Gyroscope Company.

The Aerodynamics of Compressor Blade Vibration—H. Pearson, Chief Research Engineer, Rolls-Royce Ltd., Derby.

Aircraft De-Icing by Thermal Methods—L. J. Orr, D. Fraser, and J. H. Milsum, Low Temperature Laboratory, National Aeronautical Establishment of Canada.

Some Factors Affecting Helicopter Design and Future Operations—R. H. Miller, Vice-President—Engineering, Kaman Aircraft Corporation.

Some Recent Advances in Boundary Layer and Circulation Control—Courtland D. Perkins and David C. Hazen, Professor and Assistant Professor, respectively, Department of Aeronautical Engineering, Princeton University.

Basic Prerequisites for Production—R. A. Neale, Vice-President—Manufacturing, Canadair, Ltd.

Some Observations on the Problem of Fatigue of Aeroplane Structures—R. V. Rode, Assistant Director for Research, NACA.

The Introduction of the Comet into Service—A. C. Campbell Orde, Operations Development Director, British Overseas Airways Corporation.

The technical sessions were brought to a formal close at 4:00 p.m. on Thursday, September 17, with brief remarks by the presidents of both societies and by Brigadier Gueterbock, Secretary of University College. In their closing remarks, both Sir William and Mr. McCarthy expressed the opinions that the Conference had been a complete success and that the two societies had accomplished the job they had set out to do. The audience's reactions to these statements indicated that the delegates of both sides concurred.

Wilbur Wright Memorial Lecture

Although not directly connected with the Conference, the traditional Wilbur Wright Memorial Lecture has been scheduled to coincide with Conference meeting dates during those years when the meetings have been held in England. This year's Lecture, delivered by Prof. Nicholas J. Hoff, Polytechnic Institute of Brooklyn, came on the afternoon of Monday, September 14, and was held in the auditorium of the Royal Institution on Albemarle Street.

It is also on this formal occasion that the Fellowships and Awards of The Royal Aeronautical Society are presented.

Both the Award ceremonies and the Lecture were well received by the largest audience that has ever attended these presentations. The In-

(*Continued on page 129*)

Fairchild Announces Jet Transport Plans

Plans for a high-speed commercial turbojet transport, designated the Fairchild M-186, were announced on November 17 by Fairchild Engine and Airplane Corporation's Fairchild Aircraft Division. Developed under the corporation's $1,500,000 research program, the M-186 is one of two projects now in the planning stage. The other project, currently classified, concerns a turboprop military aircraft to operate from unimproved fields.

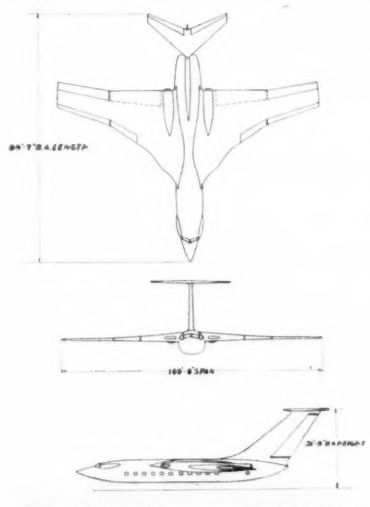
As shown in the accompanying three-view drawing of the M-186, this transport has been conceived as a high-wing transport that incorporates what Fairchild terms a "cusp" wing. The "cusp" wing, its designers point out, was developed from the delta and conventional straight wing and is not to be confused with the "crescent" wing that grew out of a combination of the swept-back and straight wings. The wing span of the M-186 measures 100 ft. exactly. The ship's overall length is 98 ft., 7 in., and its overall height is 31 ft., 8 in.

Fairchild's jet transport will be powered with two Wright J-65 turbojet engines, this type of power plant giving an estimated thrust of 12,000 lbs. minimum. These engines, located slightly aft of the passenger compartment, would enable the M-186 to cruise at 570 m.p.h. (495 knots).

Normally, the plane will carry a crew of three and 44 passengers, with provisions for navigator and radio operator. By employing high-density seating for air-coach operations, up to 64 passengers could be accommodated. It is planned to equip the ship with APS-42 search radar, as well as with the standard air-line communications and navigational instruments.

According to present plans, the new Fairchild transport is designed to operate normally on coast-to-coast runs with only one refueling stop. However, by using external leading-edge wing tanks, the ship could accomplish this transcontinental run nonstop.

Proposed plans for this aircraft show it as a transport that could be readily converted to bulk freight operations. As a transport, its normal gross weight is listed as 75,000 lbs. In cargo operations, it would have a 35,000-lb. pay load.



Three views of the new commercial jet transport, developed by the Fairchild Aircraft Division of Fairchild Engine and Airplane Corporation.

AGARD's Third General Assembly and Aeronautical Seminar

The Advisory Group for Aeronautical Research and Development of the North Atlantic Treaty Organization held its Third General Assembly at the Institute of Civil Engineers in London, England, from September 3 to 11.

More than 100 delegates and representatives from eleven countries gathered to formulate plans for mobilizing aeronautical science behind the NATO military effort.

The opening address of welcome was given by the Rt. Hon. George Ward, M.P., Parliamentary Under Secretary of State for Air, United Kingdom. A review of aeronautical research during the last 10 years was presented by Sir Harry M. Garner, K.B.E., C.B., formerly Chief Scientist of the United Kingdom's Ministry of Supply. Sir Harry traced the pattern of recent significant developments and indicated their significance for future trends.

In addition to being greeted by Mr. Ward and Sir Harry, the delegates were also welcomed at the Assembly's formal opening by Brig. Gen. F. van Rolleghem, Belgium Air Force; Rear Adm. Casper John, C.B., Deputy Controller of Supplies (Air), Ministry of Supply, U.K.; Gen. Pierre Fay, Chief of Staff, French Air Force; Lt. Gen. L. C. Craigie, Deputy Chief of Staff for Development, USAF; Gen. S. Yalistras, Deputy Minister of Air, Greece; and Dr. O. H. Wansbrough-Jones, Chief Scientist, Ministry of Supply, U.K.

All participants in AGARD's Third General Assembly were invited to attend the SBAC Flying Display and Exhibition, the dates of which overlapped those of the General Assembly. In addition, the AGARD National Delegates and Panel Members were invited by the Royal Aeronautical Society to be Temporary Honorary Members of the Society and to attend the Fourth Anglo-American Conference, under joint RAeS-IAS sponsorship. (The Anglo-American Conference met the week following the AGARD General Assembly.)

AGARD was established in 1952 by the Standing Group of NATO to bring together leading aeronautical personalities of the NATO countries with a view toward recommending effective ways in which to utilize their research and development personnel and facilities for the mutual benefit of the NATO community. The USAF was designated as initial Executive Agent, and Dr. Theodore von Kármán, IAS Honorary Fellow and Founder Member, was appointed Chairman. A Secretariat was established in the Palais de Chaillot, Paris, France, with Dr. F. L. Wattendorf, FIAS, as Director and B. J. Driscoll, MIAS, as Associate Director.

The group consists of several National Delegates from each of the NATO nations, who are prominent scientifically in the defense effort of their respective countries. The two National Delegates from the United States are Dr. von Kármán and Dr. Hugh L. Dryden, IAS Honorary Fellow, Honorary Member, and Founder Member.

AGARD activities have been concentrated in the fields of wind-tunnel design and operation, flight-testing techniques, aeromedicine, combustion research, and aeronautical documentation. To carry out this work, four panels have been appointed for the first four above-mentioned fields. A Documentation Committee covers the fifth field. All panels and the committee have international representation.

▶ **Aeronautical Seminar**—Acting upon a recommendation by the Italian Delegation to AGARD, an Aeronautical Seminar was held at the Consiglio Nazionale delle Ricerche, Rome, Italy, from September 14 to 24. The Seminar was prepared and organized by the University of Rome's School of Aeronautical Engineering with the combined support and assistance of AGARD, the Italian Ministry for Defense—Air Force, and the Consiglio Nazionale delle Richerche.

During the first meeting, Prof. L. Broglio, President of the School of Engineering, discussed the objectives of the Seminar; Prof. E. Pistolesi expressed the best wishes of the Italian scientists, and Gen. F. Silvestri, Secretary of the Ministry of Air, delivered a welcoming address in the name of the Secretary of State for Defense.

The Seminar meetings were continued through September 23, with lectures being delivered on the following problems: high-speed wind-tunnel testing techniques, by Prof. A. Ferri, Brooklyn Polytechnic Institute; selected problems of high-speed aerodynamics, by Professor Ferri; thermal effects on aircraft structures at high air speeds, by Prof. M. A. Brull, University of Michigan; behavior of materials at high tem-

(*Continued on page 63*)

IAS President for 1954

J. L. ATWOOD

President, North American Aviation, Inc.

Editorial

Changeover

Comes once more that time of year when the Presidency of the Institute changes hands. On January 25 at the Honors Night Dinner, Charles J. McCarthy joins the ranks of our Past-Presidents and J. L. Atwood takes over for the coming year.

The Institute has been more than fortunate in the men who have served as its presidents. It is a curious fact that, the busier a man is on his own job, the more time and interest he puts into the Institute's affairs during his term of office. President McCarthy has been no exception. Although under continuous and heavy pressure as an officer of a company heavily involved in the defense effort, he has made himself available at all times to your Officers and Council and has taken active part in many IAS activities here and abroad. His leadership during the Fourth International Aeronautical Conference in London will be long remembered by all who participated. His wise guidance in handling the Institute's increasingly complex business affairs has contributed greatly to the solid fiscal position of this organization as the year ends. We all owe him a rising vote of thanks as he steps down from office. As is customary, he will be a member of the Council during the current year, and we will continue to benefit from his good sense and good judgment in that capacity.

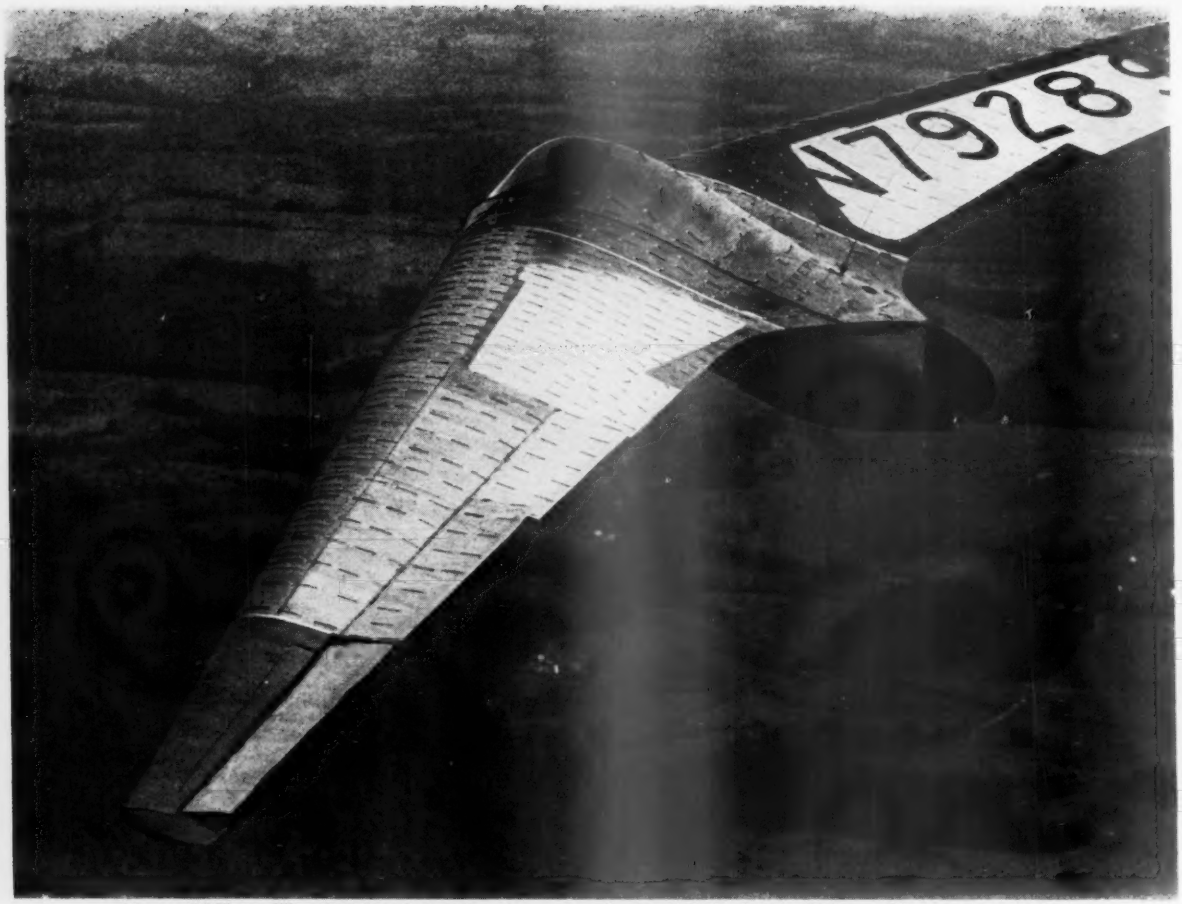
To Lee Atwood, as he takes over, we all extend our congratulations and our promise of support during the year ahead. Another extremely busy man, he has accepted the office with a heavy outside responsibility on his shoulders. He will be aided by an able group of IAS Vice-Presidents and backed to the hilt by the staff. We are glad to have him aboard.

S. P. J.

IAS President for 1953

C. J. McCARTHY

Vice-President, United Aircraft Corporation



Horten IV Flying Wing Sailplane being flown in a series of research flights by Ray Parker. Photograph was taken at 39 m.p.h., $C_L = 0.85$. Note the badly separated flow over cockpit hatch.

Flight Measurements of Trailing-Edge Suction on a Sailplane

AUGUST RASPET* and GLENN D. BRYANT*

Mississippi State College

SUMMARY

This paper concerns an investigation made on a sailplane equipped with a trailing-edge suction slot that covers two-thirds of the wing span. Special wing tips based on Hoerner's work[1] were installed and explored for pressure distribution. An experimental iteration method was used to arrive at a location and shape for the opening on the tip's upper surface which would yield a high suction pressure. The flow coefficient obtained was of an order that should have resulted in aerodynamic improvements similar to those measured on a section of the same airfoil and discussed in a previous work by Raspet.[2]

The results obtained in these tests, however, hold no promise for application of automatic trailing-edge suction to airplanes in general. No improvement in the lift/drag ratio was found, nor was there any essential improvement in overall drag. The maximum lift coefficient was not increased beyond that obtainable on a plain wing. Rolling response measurements of a fully asymmetrical distribution of suction through the trailing-edge slot yielded a roll rate about 10 per cent of that developed by the ailerons.

Additional flight measurements were made using a battery-driven axial blower to induce a flow into the trailing-edge slot. These measurements showed a maximum lift amplification $\Delta C_L/C_Q = 35$, using a trailing-edge slot similar to that found by Princeton University researchers[7] to yield a maximum lift amplification of 55.

SYMBOLS

ΔC_L	=	increment in lift coefficient
C_Q	=	suction flow coefficient $C_Q = Q/V.S.$
Q	=	quantity of airflow, cu.ft. per sec.
V	=	air speed, ft. per sec.
S	=	area of wing to which suction is applied

* Aerophysics Department, the Engineering Research Station.

q = dynamic pressure, lbs. per sq.ft.
P = static pressure, lbs. per sq.ft.
p = rolling velocity, rad. per sec.
b = wing span, ft.

Introduction

In two papers,[3, 4] Regenscheit described a wind-tunnel research into the properties of trailing-edge suction. In reference 4 he took up the possibilities of obtaining self-induced suction by utilizing the wing-tip vortex. Lippisch[5] later suggested the top of a square wing tip as being a desirable location for the suction opening. In the work described in this paper, Hoerner's concept of a tip intended to push the tip vortex outward from the tip was constructed. The upper surface of this tip yielded an area that proved to be a good source of suction.

Arrangement of Experimental Sailplane

A standard TG-3A war surplus sailplane was used in these tests. The wing was completely rebuilt in order to provide a precise outside contour, an interior offering low internal pressure losses to the flow, and tips capable of furnishing large suction pressures.

Figs. 1 and 2 show a view of the experimental wing. Additional ribs and small riblets were added behind the spars in order to prevent the fabric's deflection under suction pressures. The leading edge of the wing up to 34 per cent of the chord was controlled to a waviness of less than ± 0.004 in., which was measured with a surface gage of the spherometer type having fixed outside control points spaced at 2.4 in.—i.e., 4 per cent of the chord.

In addition, the truss ribs had all of their corners rounded, and the plywood gussets were filled with putty. This was done to reduce the pressure losses due to the internal flow.

The trailing edge was so constructed that various inserts could be placed in the slot. This permitted the slot position to be moved over a small region of the chord. The slot inserts were designed as diffusers in order to recover some of the pressure energy of the flow (see Fig. 3). Even with relatively small flows through the slot, one would find high velocities in the tip section. For this reason, the wing near the tip was constructed as a double-skinned surface and thereby had a completely hollow interior except for a small steel strut supporting the aileron. The tip itself was made hollow in order to permit air flow through its interior.

At the root of the wing an opening was provided through which air could flow from the fuselage to the wing tip through the wing's interior. This permitted measurements of flow rates to be made through the tip with a calibrating venturi installed in the root opening.

In order to have a larger cross section at the tip, about 18 in. were cut off the tip end of the wing and a new tip design (shown in Fig. 4) was installed. The aileron was thereby reduced to 5.5 per cent of the wing area.

Investigation of Tip as Suction Source

A simple pressure distribution of the top surface of the wing was first made (Fig. 5). In this illustration the pressures are shown as ratios of the dynamic pressure. Since the flow out through this surface would alter the pressure distributions, it was felt best to approach the optimum slot shape by a series of successive cuts rather than by cutting an opening in the tip surface which followed an isobar of the value corresponding to the desired suction pressure. For this reason a small

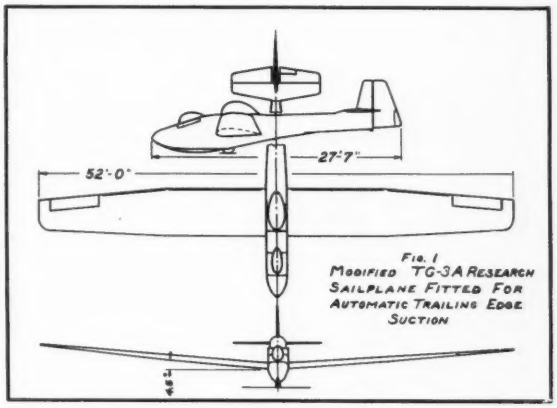


Fig. 1
Modified TG-3A Research Sailplane Fitted For Automatic Trailing Edge Suction

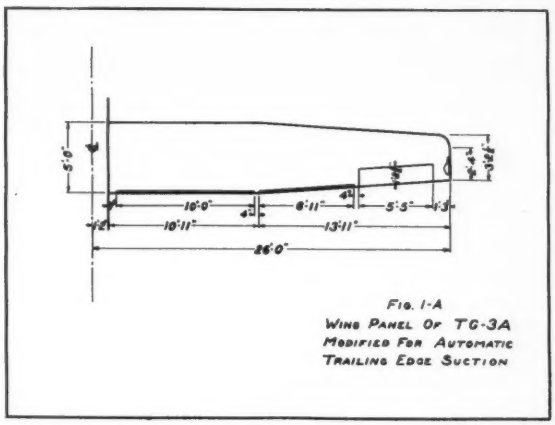


Fig. 1-A
Wing Panel Of TG-3A Modified For Automatic Trailing Edge Suction

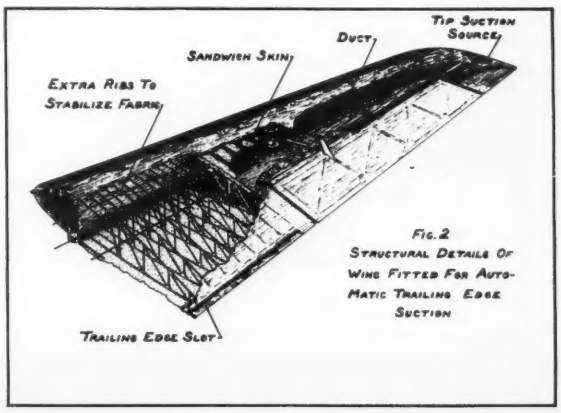


Fig. 2
Structural Details Of Wing Fitted For Automatic Trailing Edge Suction

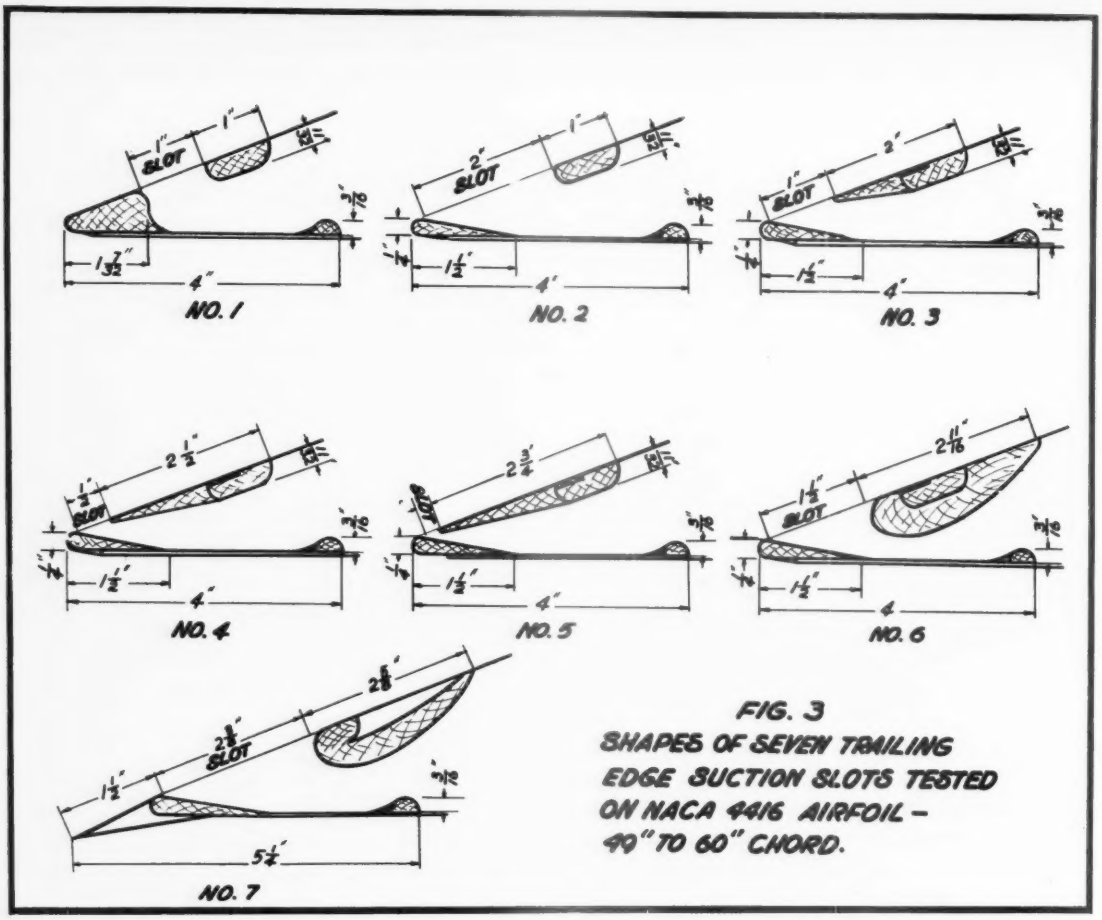


FIG. 3
SHAPES OF SEVEN TRAILING EDGE SUCTION SLOTS TESTED ON NACA 4416 AIRFOIL — 49" TO 60" CHORD.

opening following the isobar, -1.8, at high lift coefficient, was cut in the surface and a second pressure distribution was surveyed (Fig. 6). This operation was performed until the shape of the opening approximately followed the isobar, $-1.0q$. This opening yielded a flow coefficient of 0.001 at $C_L = 1.4$ through the No. 1 slot (see Figs. 7, 8, and 9).

By means of a calibrated venturi flowmeter built into the wing tip itself, a series of measurements of flow coefficient as a function of lift coefficient of the sailplane was made for each of the slot shapes. Measurements for the slot extending over 17.8 ft. of each wing are shown in Fig. 10.

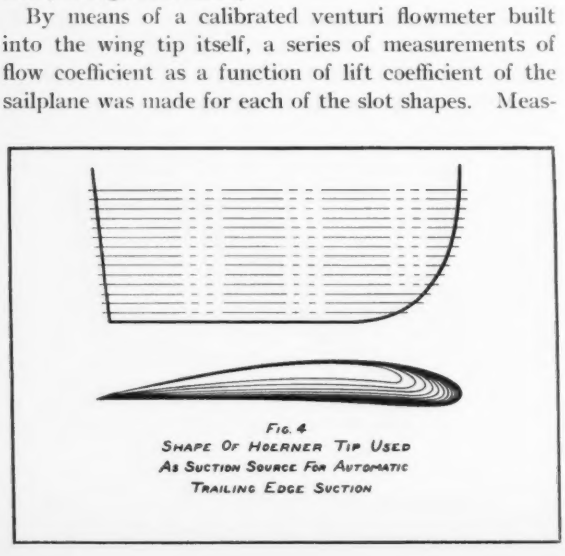


FIG. 4
SHAPE OF HOERNER TIP USED AS SUCTION SOURCE FOR AUTOMATIC TRAILING EDGE SUCTION

DRAG-POLAR DETERMINATION

The drag polar of an airplane is an excellent criterion of the performance of the airplane. On a sailplane, where no engine effects need be considered, the drag polar is the sole criterion. If trailing-edge suction is to offer economic advantages in air commerce, it must show an improvement in the drag polar over that of the clean wing. Such a polar comparison is shown in Fig. 11. These polars were obtained by averaging six independent flight tests of each configuration. The flight tests were made at early dawn in still air by measuring the sinking speed of the sailplane at various forward speeds.

It is evident from these results that the drag polar is slightly improved by automatic trailing-edge suction at lift coefficients 0.9 to 1.2. At low lift coefficients corresponding to cruising flight, the wing with trailing-edge suction has a higher drag than a normal wing. This is also true at lift coefficients above 1.2.

A similar measurement was made on the sailplane with a 2-in. wide slot extending nearly to the trailing

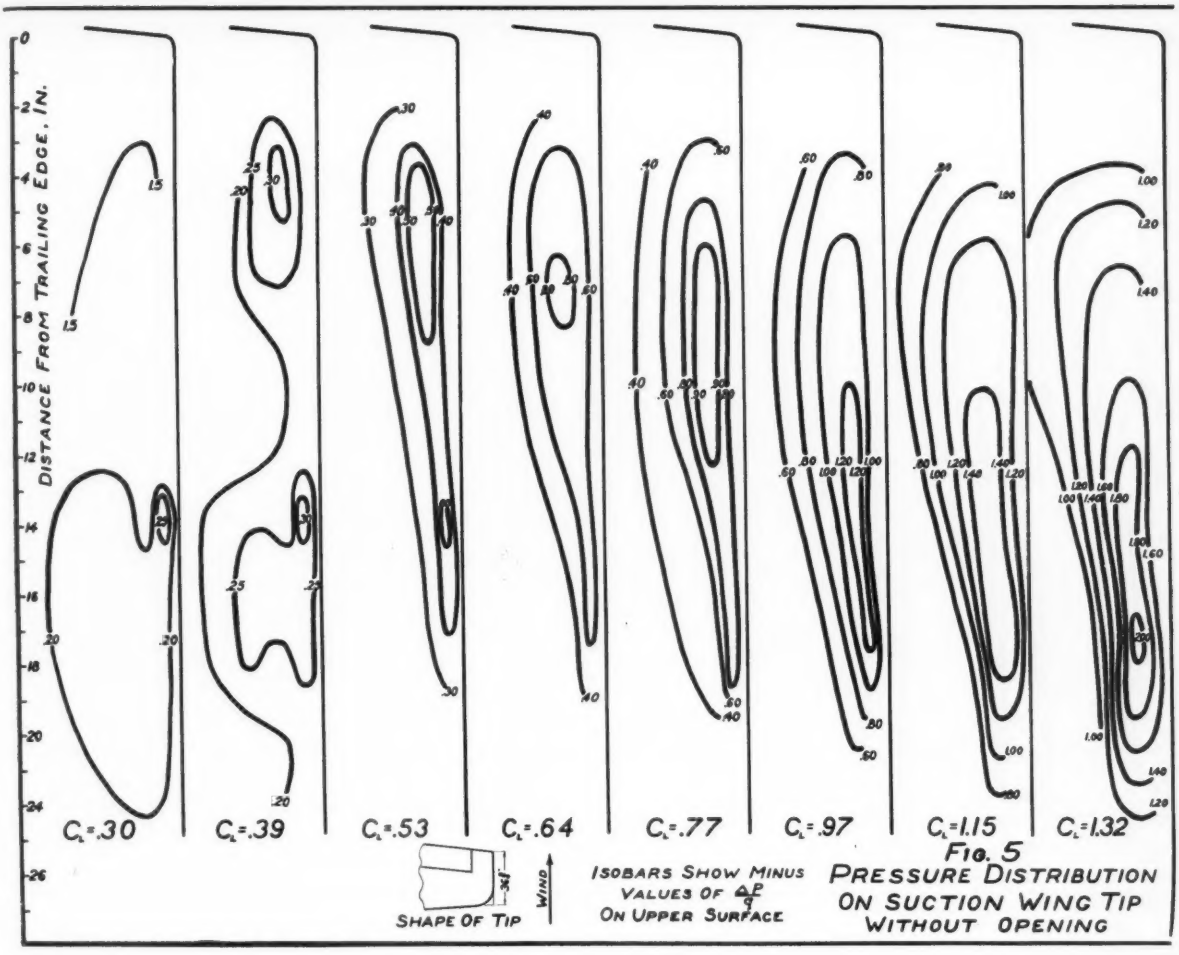


FIG. 5 PRESSURE DISTRIBUTION ON SUCTION WING TIP WITHOUT OPENING

edge (Fig. 12). In this case the drag polar for the plain wing shows a lower drag for the entire flight range of the sailplane. This would indicate that at a higher flow coefficient the drag tends to increase. Such a conclusion is supported by results obtained in earlier suction tests (Fig. 4 of reference 2). The fact that the drag polar is not improved as much at high lift coefficients as was expected from these section tests led to an investigation by a drag-polar determination of the sailplane with air flowing out of the tip openings but with trailing edge slots closed. The air required for the flow was obtained at an inlet on the nose of the fuselage. Fig. 13 shows that the aerodynamic effect of the flow through the opening used as an automatic suction source is to increase the drag at low lift coefficients. At moderate to maximum lift coefficients there is no effect on the lift-drag polar. From this measurement it may be inferred either that the losses inside the wing are of a magnitude equal to any gains in drag or that the lift increment due to trailing edge suction was nullified by an adverse effect on the lift by the flow through the tip. The rolling response measurements to be described later bear out the latter conclusion.

Rolling Response Measurements Using Full Asymmetric Trailing-Edge Suction

One of the rather intriguing ideas presented by Regenscheit was that of using automatic trailing-edge suction as a lateral control[6] and thus eliminating the movable flap. With such a control, aileron flutter would not be a consideration in airplane design. The use of an autopilot would be simplified because the servo would need to include only a flow control valve or a small tongue valve in the trailing edge of the wing, permitting flow through a slot either on top or bottom surface of trailing edge.

The technique in the evaluation of automatic trailing-edge suction as a lateral control consisted simply of closing the slot on one side of the wing while allowing the other to operate through automatic suction from the opening in the upper surface of the wing tip. In flight, the rolling tendency of the asymmetrical automatic trailing-edge suction was counteracted with a deflection of the normal ailerons, maintaining the skid at zero by means of a tuft indicator on the nose of the fuselage. The geometry of the wing used is as follows:

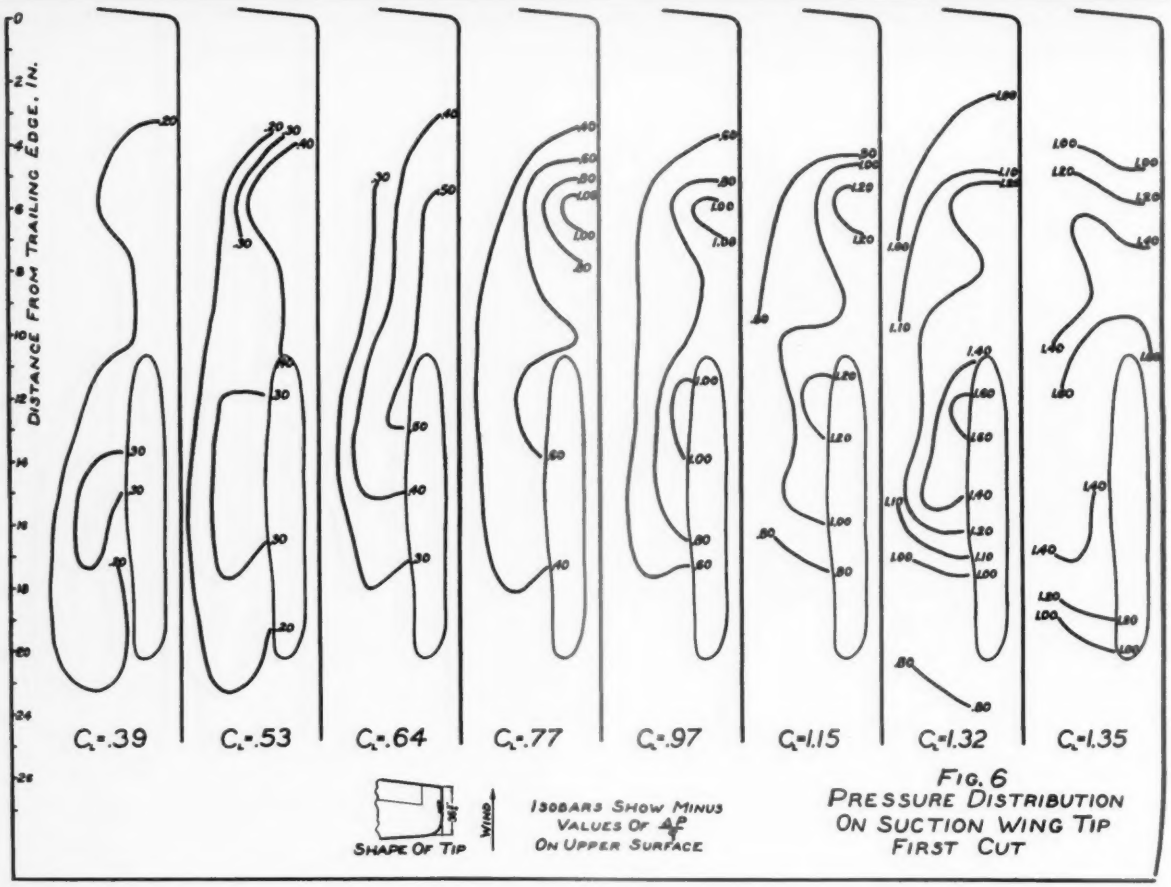


FIG. 6
PRESSURE DISTRIBUTION ON SUCTION WING TIP FIRST CUT

Wing span	52.0 ft.
Wing area total	233.3 sq.ft.
Aspect ratio	11.5
Intercepted fuselage area	10.4 sq. ft.
Aileron area, both	13.04 sq.ft.
Aileron chord	1.26 ft.
Root chord of wing	5.00 ft.
Tip chord of wing	3.21 ft.
Taper ratio (weighted)	0.824
Aileron area/wing area	0.056

Flight tests of the automatic trailing-edge suction lateral control showed, in general, very weak rolling moments. This behavior is in agreement with maximum lift determinations made by measuring the stalling speed with various trailing-edge slot designs. Only near the stall speed was sufficient rolling effect observed to be definitely measurable. With the full-length slot (17.8 ft.), the maximum rolling responses were determined and are shown in Table 1.

TABLE 1

Slot	Aileron Deflection	$pb/2V$
No. 1	1.9°	0.0088
No. 3	1.4°	0.0066
No. 4	0.95°	0.0044
No. 5	0.47°	0.0022

Since the values of helix angle $pb/2V$ are extremely small, of the order of 0.1 of the values for desirable lateral control, an effort was made to improve this control by concentrating the suction toward the outboard section of the slot just inboard of the small aileron. The effect was an increase both in the suction-flow coefficient and in the moment arm for the applied lift force generated by the suction. The flow coefficient obtained from measurements in flight with the outboard 66 in. of the slot opened is shown in Fig. 14. It can be seen from this figure that at high lift coefficients a flow coefficient of 0.004 is obtained. If the slope of lift versus flow coefficient (amplification) were as high as is shown by Regenscheit,[3,4]—i.e., 100—a section lift increment of 0.4 would have resulted. This ΔC_L would require a countering total aileron deflection of 7.5°. It is clearly evident from Table 2 that no such effectiveness was observed.

TABLE 2
Maximum Rolling Response—Outboard 66 In. of Slot Open

Slot	Aileron Deflection	$pb/2V$
No. 1	0.95°	0.0044
No. 3	1.90°	0.0088
No. 4	1.43°	0.0066
No. 5	0.95°	0.0044

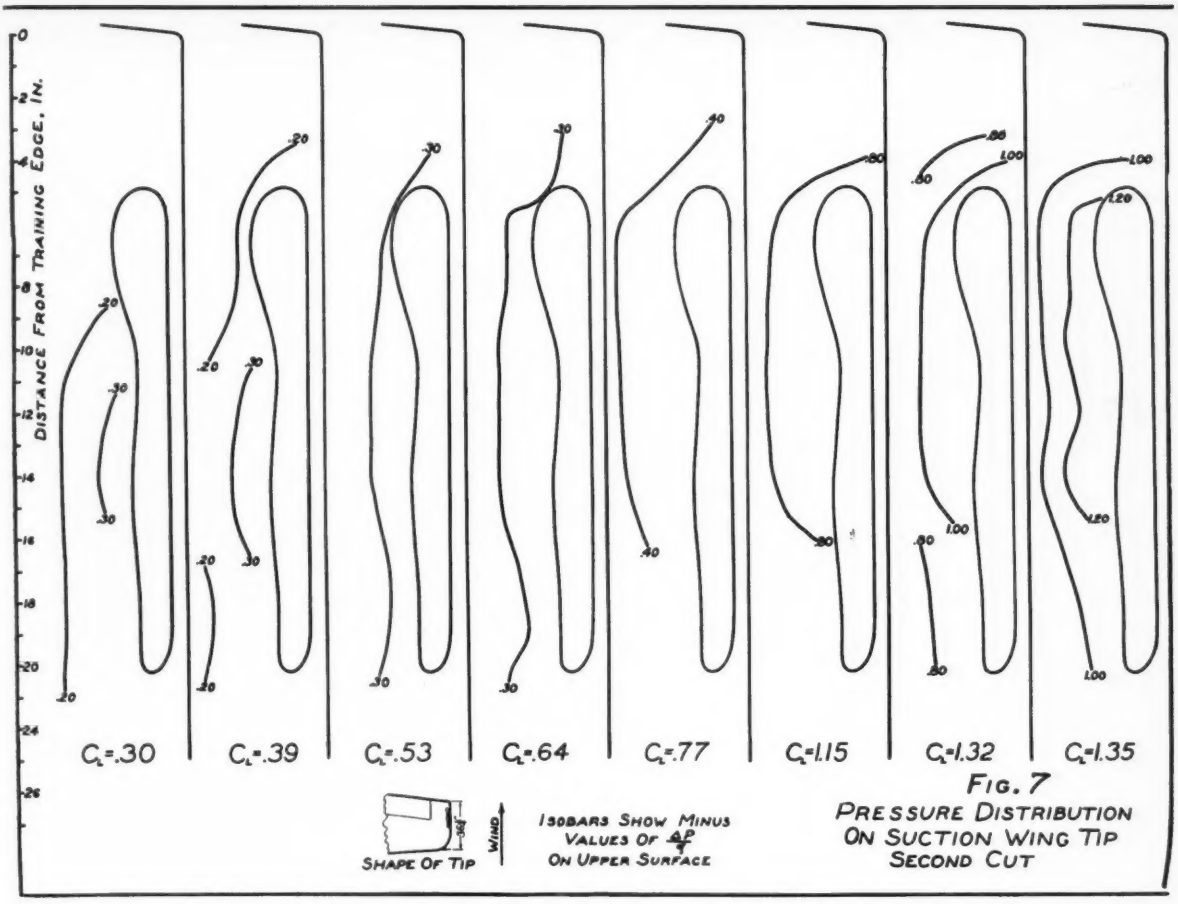


FIG. 7
PRESSURE DISTRIBUTION ON SUCTION WING TIP SECOND CUT

In general, though the concentration of slot outboard resulted in an essential increase in helix angle, the results obtained would still not indicate sufficient control for safe flight operations.

From these results one must conclude that, with present configurations of slot and tip opening, a lateral control system utilizing automatic trailing-edge suction would be totally unsuitable because it lacks sufficient effectiveness for lateral control, even in still air.

Maximum Lift Coefficient

Since the suction induced by the wing tip vortex increases with the lift coefficient, one would expect, if trailing edge suction controls the turbulent separation, a relatively large increment in maximum lift coefficient. This can readily be measured by the decrease in minimum speed. Figs. 11 and 12 give the maximum lift coefficients so measured as follows:

Clean ship—no slot	max. $C_L = 1.43$
No. 1 slot open full length	max. $C_L = 1.37$
No. 2 slot open full length	max. $C_L = 1.36$

It is evident from these values that there is a small loss of maximum lift coefficient with trailing-edge suction and a wing-tip source. The exact behavior of the slot action must yet be determined in its full open-span length with an independent source of suction such as an electric blower. This would permit the lift increment to be determined over a range of flow coefficients, thereby separating the effect of the tip suction sources on lift from those of the trailing-edge slot and would yield measurements similar to those made on a section,[2] except that the slot would cover at least two-thirds of the span.

Improvement of Tip Suction Source

In an effort to improve the suction flow through the tip opening, a deflector 1 in. high was installed in the inboard edge of the tip opening. No effort was made to duct the flow internally through the tip. A comparison of the flow through the original opening, and the same with the deflector, is shown in Fig. 15. Approximately 30 per cent more flow is gained at low lift coefficients.

It was felt, however, that the drag of the additional deflector would not be compensated by any overall decrease in drag due to the trailing-edge suction. If an efficient trailing-edge suction configuration is eventually developed, the deflector might fulfill a useful function.

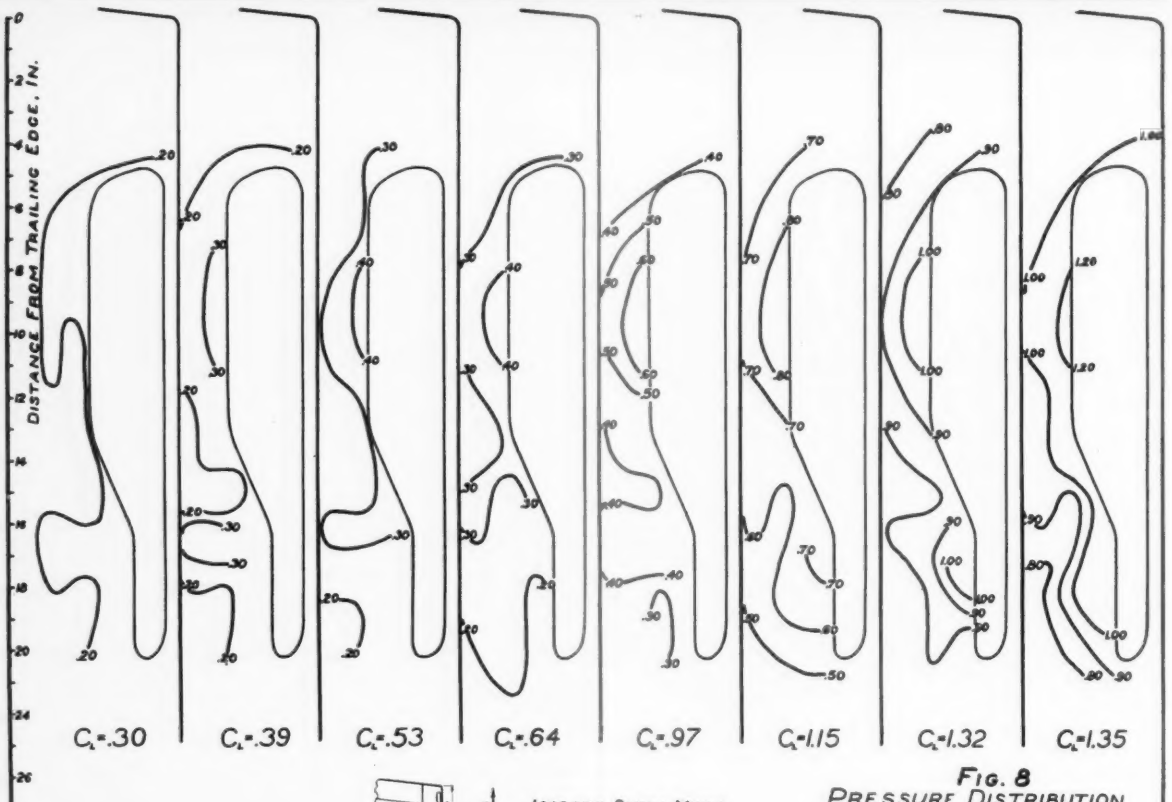


FIG. 8
PRESSURE DISTRIBUTION ON SUCTION WING TIP THIRD CUT

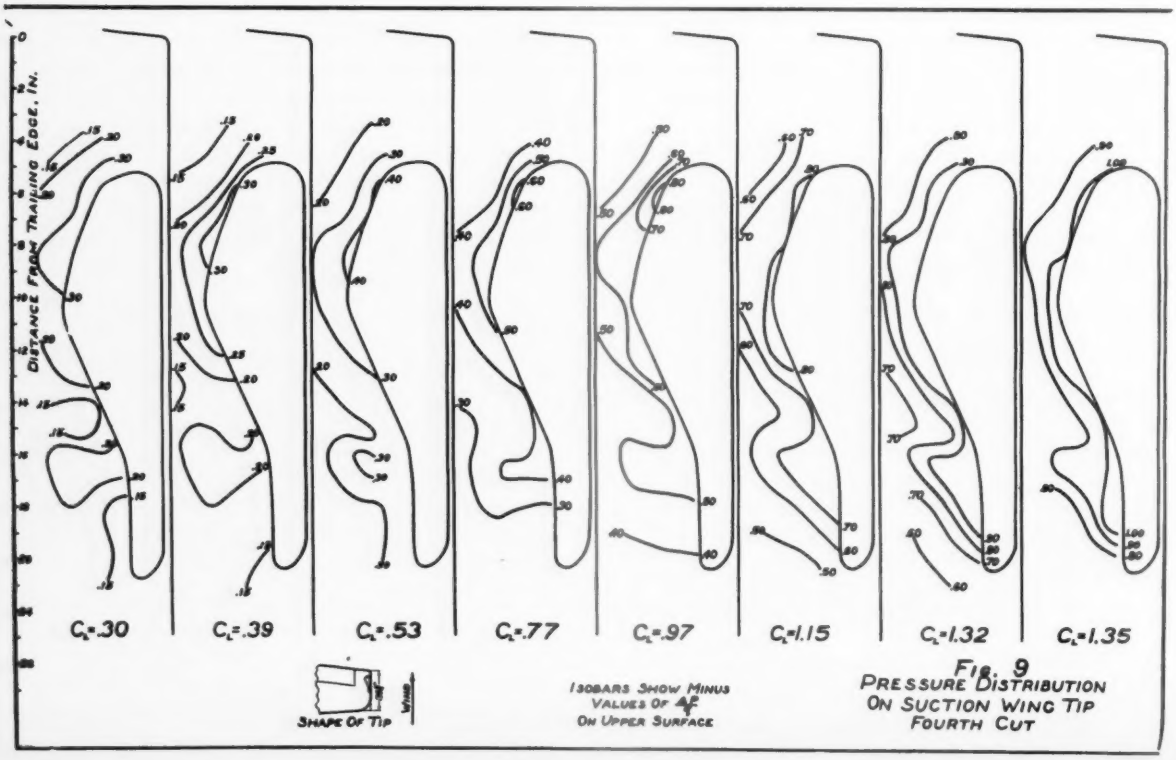


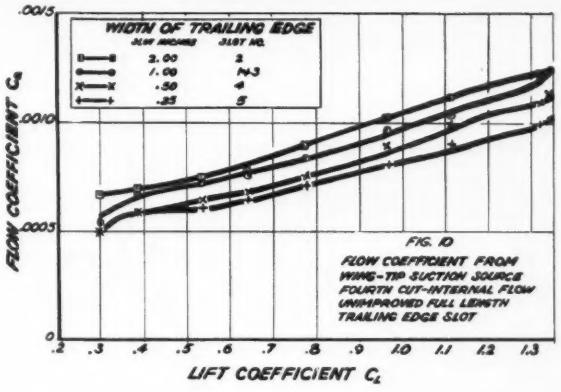
FIG. 9
PRESSURE DISTRIBUTION ON SUCTION WING TIP FOURTH CUT

Suction Flow Induced by Blower

In order to determine the effectiveness of trailing-edge suction separated from the tip effects resulting from flow through the tips, a series of flight tests using an axial blower for suction were made. These tests were made by flying at constant angle of attack by means of a yawhead type of angle of attack instrument. This instrument was mounted on a mast 1.2 root-chords above the chord line of the wing. The angle of attack meter was used to ensure that the measurements made with blower-on and blower-off would be made at the same angle of attack.

The lift coefficient of the wing was obtained by integrating the chordwise lift distribution recorded on a photomanometer. The pressure differentials between top and bottom surfaces were obtained from two plastic belts of ten tubes each. In all, 19 pressure differentials were thus recorded. A typical lift distribution is shown in Fig. 16.

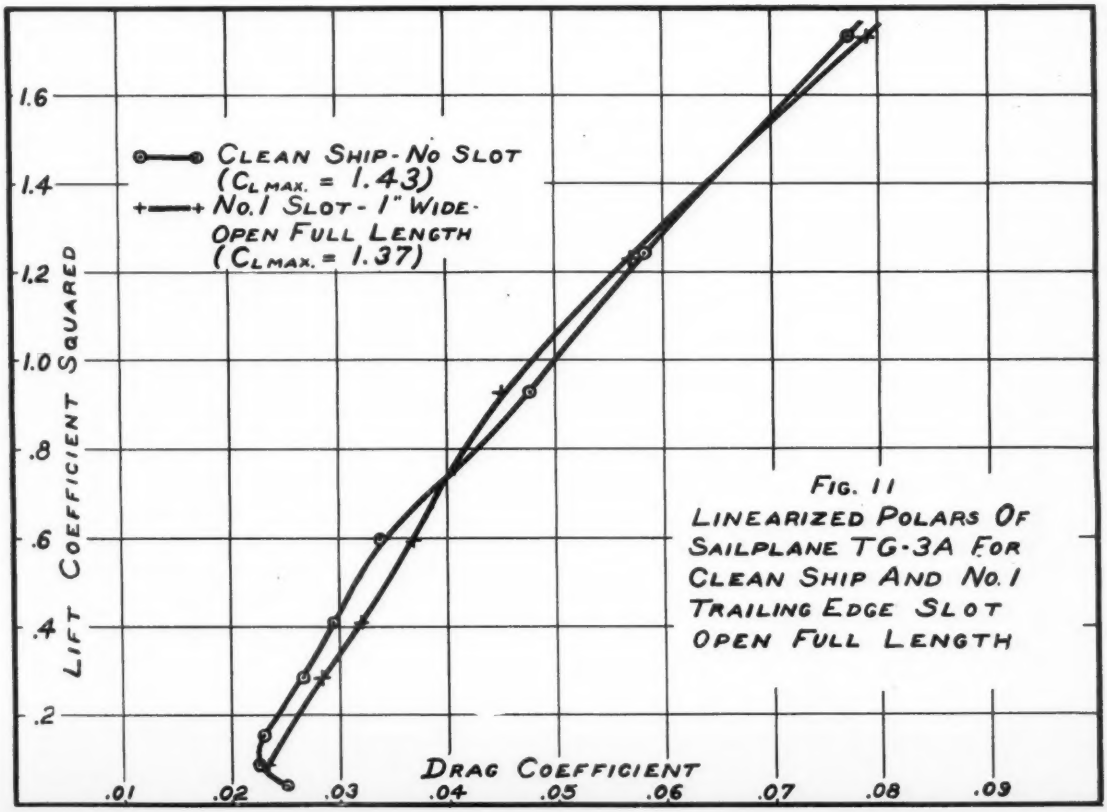
For the suction, an axial blower capable of pumping 1,500 cu.ft. of air per min. was driven by a storage battery in the sailplane. The blower exhausted the pumped air rearward in the flight direction. The flow coefficients that were reached by this pumping system are displayed in Fig. 17. Suction was applied to one wing only. Measurements were made while maintaining symmetrical flight using aileron and rudder to compensate for additional lift on the suction wing.



The results of the flight measurements, Fig. 17, showed that the lift amplification reaches a peak at the stalling speed of the airfoil. This would indicate that the function of the trailing-edge suction, in this case, was one of separation prevention, perhaps through the sink effect resulting from the slot suction.

Conclusions

A suction source capable of yielding a maximum suction of $2q$ with no flow at a lift coefficient of 1.4 was found by an iteration process on the upper surface of a Hoerner tip. This suction source yielded a flow coefficient of 0.0023 with a trailing-edge slot covering 65 per cent of the span of the sailplane used in this research.



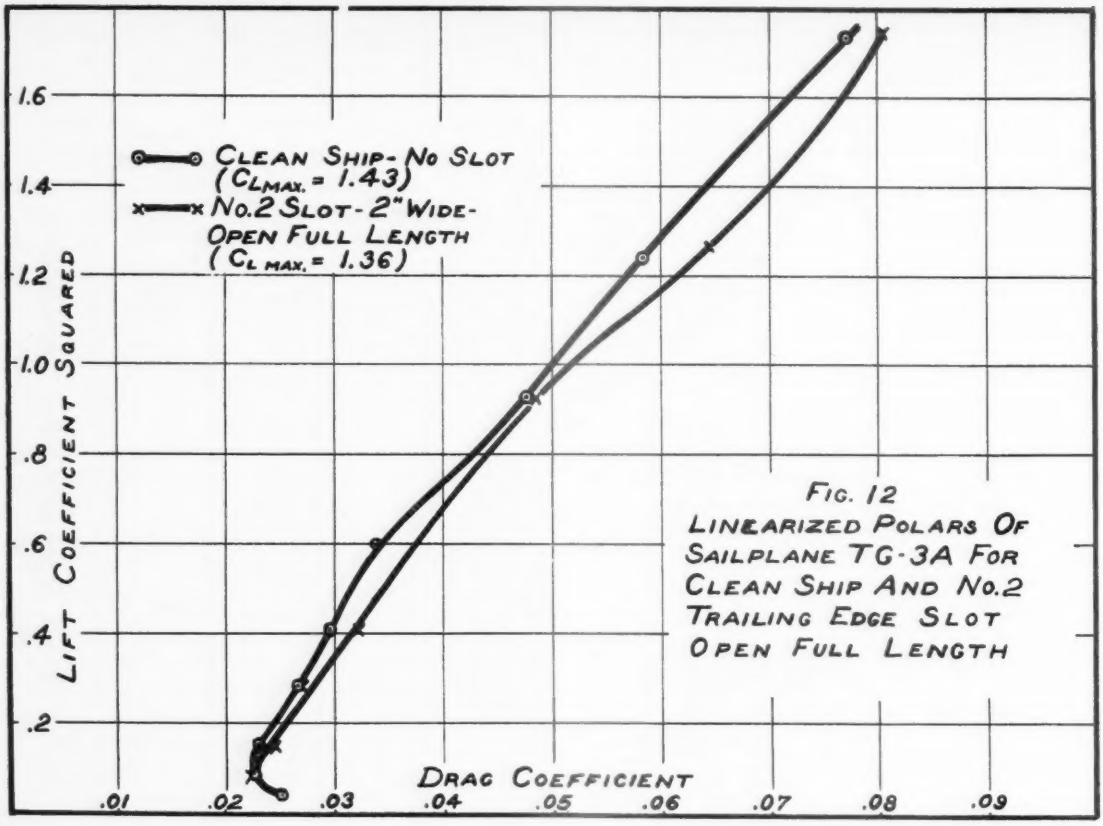


FIG. 12
LINEARIZED POLARS OF SAILPLANE TG-3A FOR CLEAN SHIP AND NO.2 TRAILING EDGE SLOT OPEN FULL LENGTH

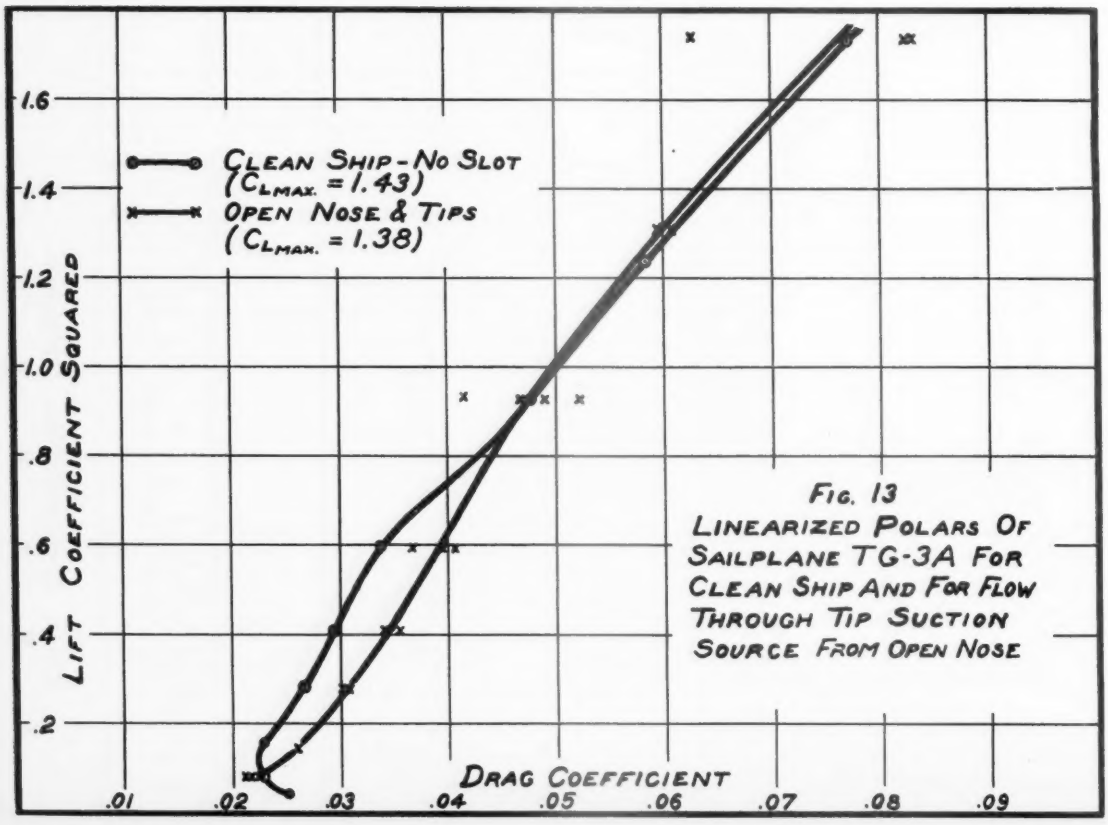


FIG. 13
LINEARIZED POLARS OF SAILPLANE TG-3A FOR CLEAN SHIP AND FOR FLOW THROUGH TIP SUCTION SOURCE FROM OPEN NOSE

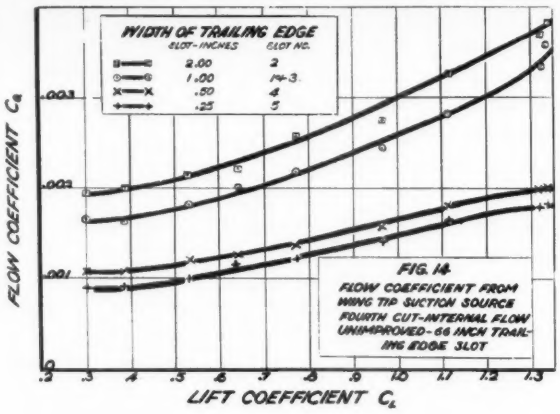


FIG. 14
FLOW COEFFICIENT FROM WING TIP SUCTION SOURCE FOURTH CUT-INTERNAL FLOW UNIMPROVED-66 INCH TRAILING EDGE SLOT

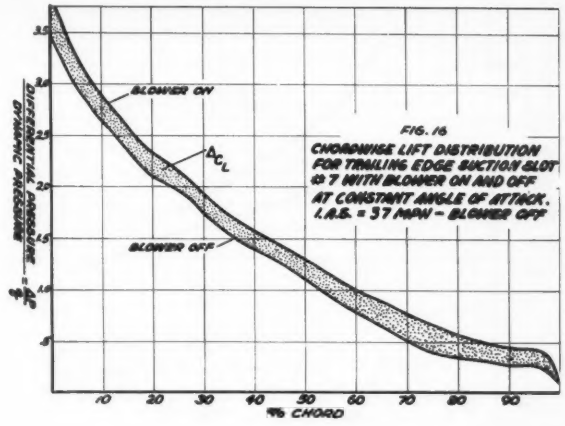


FIG. 16
CHORDWISE LIFT DISTRIBUTION FOR TRAILING EDGE SUCTION SLOT @ 7 WITH BLOWER ON AND OFF AT CONSTANT ANGLE OF ATTACK. I.A.S. = 37 MPH - BLOWER OFF

A slight improvement in suction was effected by using a deflector on the inboard edge of the suction opening. With this tip suction source connected by a low-loss ducting, through the interior of the wing, to a trailing-edge suction slot, it was found that:

(1) From a drag polar determination a loss of performance would result with automatic trailing-edge suction.

(2) The maximum lift coefficient is slightly lower when automatic trailing-edge suction is in operation than it is on a plain wing.

(3) By applying trailing-edge suction asymmetrically, a rolling behavior totally insufficient for effective lateral control was measured.

(4) Blower-induced trailing-edge suction yielded, in full-scale flight, a lift amplification slightly less than that measured on an 8-in. chord model in the Princeton tunnel.[7] Both the Princeton research and this were considerably below the values reported by Regenscheit.[8]

In general, the results obtained by full-scale flight tests of trailing-edge suction indicate that more work needs to be done on the possibility of combining distributed suction with trailing-edge suction. This type of flow control would more nearly fit requirements of the theoretical studies in which potential flow is assumed. Some promising preliminary results have been obtained with such a configuration.

In these tests, perforated suction was applied from the 35 per cent chord point to the slot at 97 per cent chord. When suction was applied at flight near maximum lift coefficient, a relatively strong rolling moment was found with a test section 45 in. wide and only 18 per

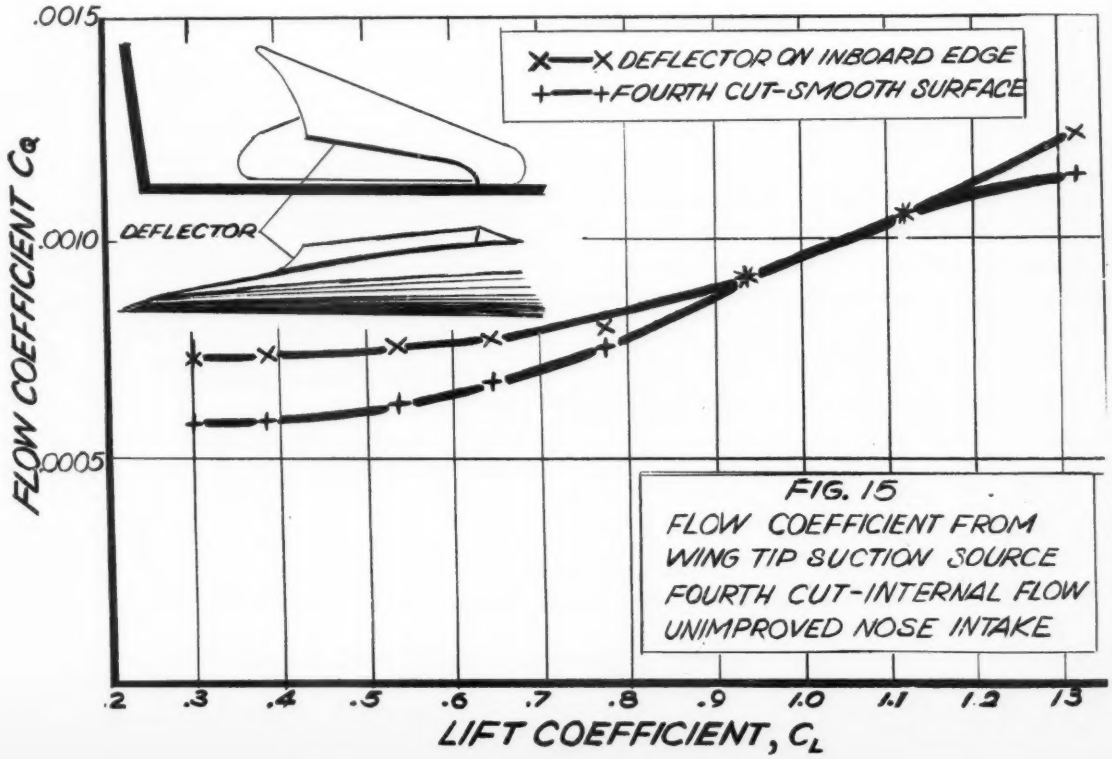
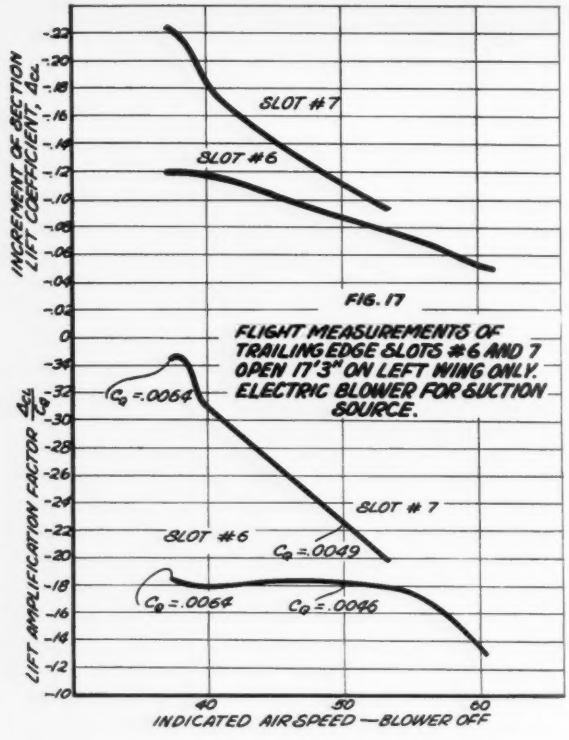


FIG. 15
FLOW COEFFICIENT FROM WING TIP SUCTION SOURCE FOURTH CUT-INTERNAL FLOW UNIMPROVED NOSE INTAKE



cent of the semispan from the fuselage centerline. This section was installed on one wing only. The study is being continued in order to evaluate distributed suction as a drag reducing and lift augmenting aerodynamic device.

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Design Features of the

XH-26 "Jet Jeep" Helicopter

HOWARD E. ROBERTS*

American Helicopter Company, Inc.

SUMMARY

This paper describes the novel features of the American Helicopter Company, Inc., XH-26 "Jet Jeep" helicopter. The XH-26 is a single-place, pulse-jet-propelled, collapsible helicopter that has been developed, under U.S. Air Force cognizance, for use by the U.S. Army in observation and reconnaissance missions.

The many novel features incorporated into the design are the result of a rigorous design philosophy that was dictated by the requirements of (a) an empty weight of 300 lbs. or less, (b) simplification of controls, (c) ability to fold up into a small package for aerial delivery in a container, (d) functional and maintenance simplicity comparable to, and requiring little more experience and tools than, a military "Jeep," and (e) being designed to meet all applicable "Handbook" and military specification requirements. It is considered the first successful military-type jet helicopter.

The success of the XH-26 in demonstrating outstanding flying qualities, excellent service and maintenance characteristics, and rugged reliability has proved the feasibility of the pulse-jet-propelled helicopter.

INTRODUCTION

MILITARY CHARACTERISTICS for a single-place, collapsible helicopter were established by the U.S. Army. The mission of this aircraft was to provide front-line aerial reconnaissance and observation for Army units during the early phase of an air-borne operation or during armored combat. The aircraft requirements were that it be collapsible and be capable of aerial delivery such that two men could assemble the aircraft ready for take-off in less than 20 min.

A design competition was held by the U.S. Air Force for the purpose of selecting the design best suited to the military characteristics requirements. In mid-1951, the American Helicopter Company, Inc., as the successful entrant, was awarded a contract for the development of this aircraft. This aircraft has been assigned the Service model designation XH-26 and carries the Company designation Model XA-8.

The type specification and military characteristics, established by the U.S. Army and Air Forces, necessitated establishing a rather rigorous design philosophy. Many new and exacting design problems were presented in the development of the XH-26. Specifically, the design task was to develop an aircraft that would (a) not exceed 300 lbs. empty weight, (b) meet all applicable HIAD (Handbook) and military specification requirements, (c) not require special tools or require mechanic's skill more specialized than an "average Army mechanic," (d) provide a rugged, serviceable, and maintenance-free vehicle, and (e) possess simple flight controls and desirable maneuverability and flying qualities.

The author wishes to express his appreciation to the U.S. Army and Air Forces for their declassification of the XH-26 project which now permits it to be completely described in the present paper.

DISCUSSION

General

The XH-26 is a single-place, collapsible, lightweight helicopter. It differs, basically, from most helicopters in that the rotor is driven by the thrust produced by a pulse-jet engine mounted at each rotor blade tip. In this system, no torque reaction exists between the rotor system and the air frame as a consequence of the rotor power requirements. It is analogous, in operating principle, to the simple "pin wheel." There is, however, a small amount of power extracted *from* the rotor system to drive accessories and the directional control rotor.

The aircraft is produced with both a tricycle and skid landing-gear configuration. Fig. 1 shows a photograph of the complete XH-26 aircraft with the skid gear configuration. Fig. 2 shows the prototype XH-26, tricycle wheel gear configuration in flight. It can be seen, in Fig. 1, that the pilot's compartment is fully enclosed. The bulged Plexiglas doors, shown in Fig. 3, together with the full windshield, low cockpit rail, and aft window, provide an exceptionally high degree of

FIG. 1. Skid gear configuration.

Presented at the Helicopter Design Session, Annual Summer Meeting, IAS, Los Angeles, July 15–17, 1953.

* Vice-President—Engineering.

FIG. 2. XH-26 prototype in flight.

FIG. 3. Front view of XH-26 showing bulged doors.

FIG. 4. XH-26 prototype in flight and in Jeep 1/4-ton trailer.

visibility in all directions. A "vee" tail is mounted to the aft fuselage to provide in-flight, static directional, and longitudinal stability.

The construction materials employed in the XH-26 aircraft are, generally speaking, conventional aircraft materials. Extensive use has been made of fiberglass-reinforced plastics, as a weight-saving material, in such components as the pilot's seat, complete aft fuselage, and tail bumper. Magnesium, aluminum, copper, titanium, and steel alloys are used in the aircraft. In each material application consideration has been given to ensure that it is best suited from the strength, weight, cost, "critical material," and service-life standpoints.

The "Jet Jeep" is designed to fold into a comparatively small aerial-delivery container. It is also designed to be transported in a standard 1/4-ton Jeep trailer, as shown in Fig. 4. The windshield is removable by disengaging four, quick-disconnect fasteners. The doors can either be removed with the windshield, as an assembly, or separately by actuating the door-jettisoning latches. The rotor blades are removed from the extension shafts by removing four bolts per blade. The upper fuselage folds forward over the instrument console. The cyclic and collective pitch controls are rigged and designed such that removing the blades and folding does not disturb the rigging of the flight controls.

A maximum of design effort has been concentrated in the XH-26 in an effort toward producing a simple, lightweight, rugged, and reliable aircraft. The design empty weight of the aircraft is 300 lbs. Its useful load consists of a pilot and parachute, portable radio, and 50 gal. of fuel.

Rotor System

The rotor system of the XH-26 helicopter is of the semirigid, teetering type. The rotor blades can be detached from the rotor hub extension shafts by removing four bolts in each blade. The pulse-jet engines are mounted at the tip of each blade and retained by two bolts. The hub assembly, shown in Fig. 5, consists of an aluminum-alloy ring, retention bearings, and extension shafts. It will be noted in Figs. 5 and 6 that the complete rotor system can be detached from the aircraft by removing the two teetering pins and disconnecting the collective pitch arms, accessory scissors, and fuel and air lines.

The teetering pins are located at the top of the hub in order that the spanwise centers of mass and aerodynamic drag correspond, as nearly as possible, to the teetering axis in flight. The teetering axis, furthermore, is designed to be in the plane of the gimbal axes about which the control shaft is tilted. Fig. 6 shows the relationship of the rotor control and the teeter axis.

The steel extension shafts are retained in the hub ring by a series of preloaded, radial-thrust ball bearings. These bearings and the extension shaft are assembled in a steel "cartridge" liner. The assembly is then in-

stalled in the ring and secured by a spanner nut. Lubrication provisions are made in the hub assembly such that all bearings may be "purged" with grease at prescribed periods of service. Bearings may be rotated periodically to reduce the effect of the wear caused by small-amplitude oscillations.

The rotor-blade pitch arms, shown in Figs. 5 and 6, bolt to the "ears" on the hub extension shaft and connect to the pitch links. The pitch arms and links to the collective pitch crossarms are designed such that, under "average flight conditions," the axis through the pitch-arm-link joints passes through the teetering axis. This arrangement minimizes the interaction between blade flapping and feathering motions.

One novel feature in the rotor system design is that the outer gimbal ring, which supports the air frame in flight, is pinned directly to the rotor support pylon. *There are no vibration isolation system or dampers incorporated in the Jet Jeep!* This feature considerably simplifies the control system kinematics and permits a teeter stop to be incorporated on the pylon against which ride self-aligning rollers mounted in the hub ring.

The initial XH-26 aircraft are being delivered with modified Prewitt Model 32 (HUP-2) stainless-steel rotor blades. The construction features of these blades have been described adequately in other papers. One of the modifications to the basic HUP-2 blade consists of a root-end truss fitting that attaches to the drag-hinge pin and trailing-edge strut pin and contains the four "barrel-nuts," into which the blade retention bolts screw. This fitting is a pinned, rigid connection to the blade since there is no drag hinge required. Other modifications consist of shortening the blade span, bonding fuel, air, and ignition lines into the blade "D" spar and securing the engine swivel-mount fitting support to the tip of the blade.

A special lightweight aluminum-alloy rotor blade is presently being developed for the XH-26 by the American Helicopter Company, Inc., which will weigh approximately 18 lbs. per blade less than the modified Prewitt blades. These lightweight blades incorporate many novel design features, and their development will be the subject of a future paper.

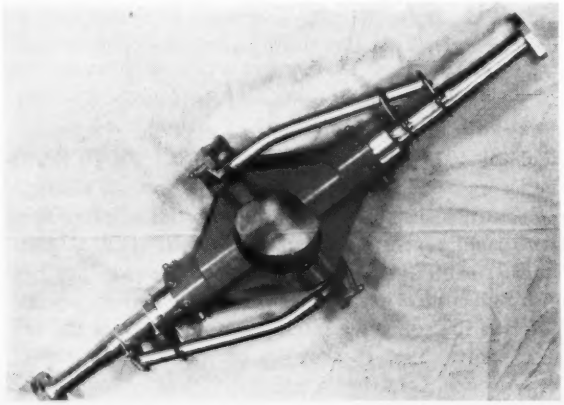

FIG. 5. Hub ring, extension shaft, and pitch arms.

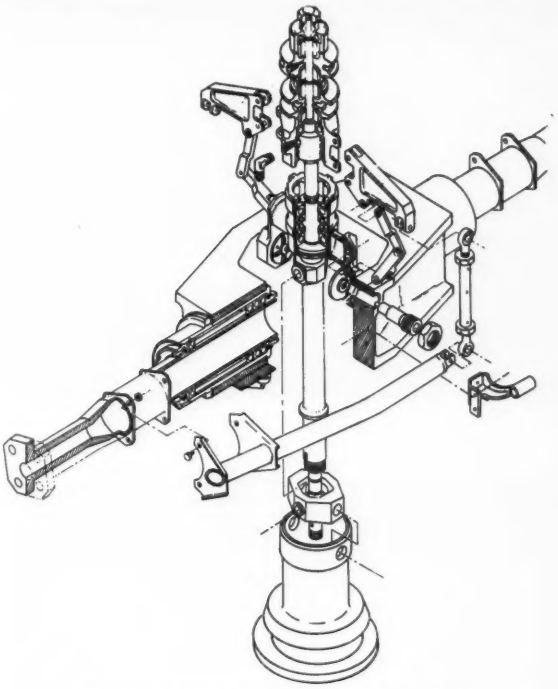

FIG. 6. Rotor hub assembly and installation.

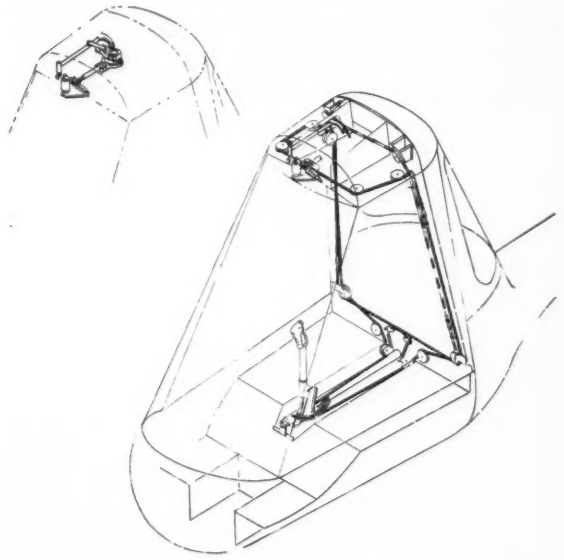

FIG. 7. Cyclic control system installation.

Controls

The primary flight controls of the XH-26 helicopter consist of cyclic and collective rotor-pitch controls, directional control, and a manual throttle control. Cyclic pitch control is obtained by direct tilting of the rotor shaft about the gimbal axes. The rotor shaft

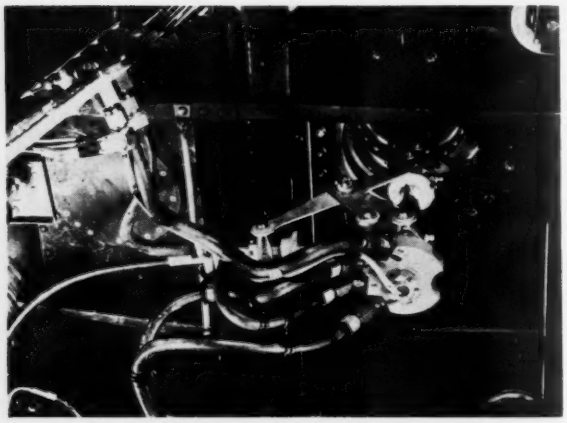

FIG. 8. Base of rotor shaft.

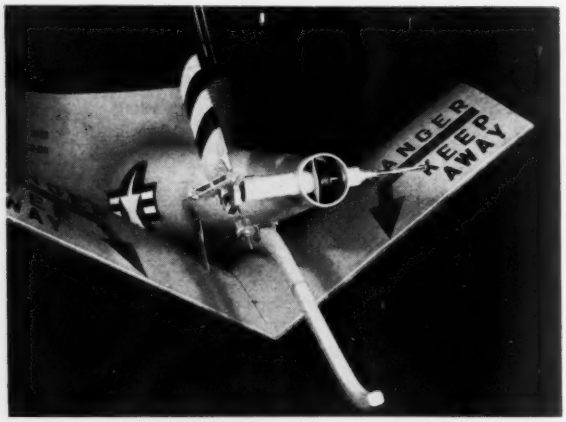

FIG. 9. "Vee" tail, tail rotor, and skid.

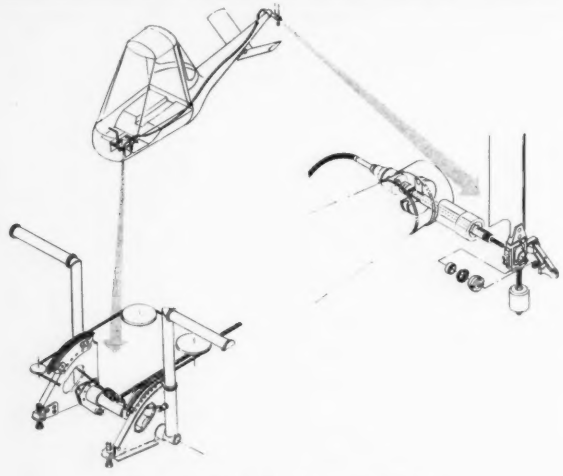

FIG. 10. Directional control system.

does not rotate; the rotor system rotates, in bearings, around the stationary shaft. Collective pitch changes are made by actuating a push-pull shaft, inside the rotor shaft, which supports the collective pitch crossarms. This raises and lowers the collective pitch crossarms and changes the pitch of both blades through the pitch links and pitch arms. This pitch control system is a basic type of helicopter control. It has the extremely desirable feature of being simple, yet eliminating any possible interaction between cyclic and collective pitch changes without the complex compensating linkages employed in the "swash-plate" type of control.

The cyclic control system consists of a conventional, centrally located, floor-mounted stick that is connected, through a reversing linkage system, to the base of the rotor shaft. The cyclic stick may be deflected in any direction, within an "HIAD"-specified square pattern, and these deflections result in a tilting of the rotor shaft *in the same direction* as the cyclic stick is tilted. Fig. 7 shows the perspective arrangement of the various sectors, cables, pulleys, bell cranks, and push rods which produce the correlated, reversed motion that is required. It is necessary to have all cyclic control cables pass horizontally through the fold axis of the aircraft where they wrap around the pulleys, mounted to the upper fuselage, at the juncture of the upper and lower fuselage. If this requirement is not observed, folding of the aircraft could result either in unrigging due to slacking or structural damage due to tightening of the cables, depending upon their eccentricity and location with respect to the fold axis. Attention is invited to the fact that there are no irreversibilities or damping devices incorporated in the cyclic control system. Control forces both in flight and on the ground are extremely light and vibration-free. A slight amount of friction has been incorporated into the system to overcome the natural instability of the cyclic stick in order to permit the pilot to fly the aircraft "hands off." The maximum control stick forces are less than 5 lbs.

The collective pitch control system is actuated by the collective pitch stick located to the left of the pilot's seat. This control is connected to a flexible push-pull control that raises and lowers the collective pitch shaft through the scissors shown in Fig. 8. The flexible push-pull control permits the necessary "excursion" of the control shaft base resulting from cyclic control displacement, without changing the collective pitch setting. An adjustable friction device and spring loaded "bungee" are incorporated into the collective pitch system to permit the collective pitch to be set and remain in a given position during a trimmed flight condition.

Directional control is achieved in the Jet-Jeep helicopter by changing the collective pitch of a small, single-bladed, directional control rotor. Fig. 9 shows the tail rotor and pitch-change mechanism. The cockpit control consists of conventional "HIAD specification" rudder pedals linked together through a "run-around" cable system, which actuates a single, flexible, push-pull control extending from the right rudder pedal sector to the collective pitch push-pull shaft in the tail rotor shaft. Fig. 10 shows a perspective drawing of the components of the directional control system. The adjustable rudder pedals are of interest from the stand-

point of simplicity, reliability, and ruggedness. The adjustment consists of simply rotating the rudder pedal *toward* the pilot which disengages a "dog" from a series of pins and permits the pedal to be moved toward or away from the pilot before re-engagement. Re-engagement is accomplished by *releasing* the spring-loaded pedal, and the "dog" again engages a pin. This feature not only assures *positive* engagement but permits easy adjustment. In extremely cold climates the adjustment can be made easily by pilots wearing heavy flying boots or heavy gloves.

The single-bladed directional control rotor is a design feature of considerable interest. The reason for selecting a single-bladed, counterbalanced rotor is that it eliminates the requirement for blade retention bearings that exist in multibladed rotors. The pitch changes are accomplished by rotating the hub, to which the blade is bolted, about the rotor span axis. A further simplification in the Jet Jeep tail rotor, resulting from its small size, is in the elimination of teetering or flapping hinge in the rotor.

The throttle control system of the XH-26 helicopter consists of a manually operated dual-throttle valve. The throttle valve is mounted to the base of the collective pitch stick, as shown in Fig. 11. The needles of this valve are spring-loaded against contoured rotary cams. The rotary cams are locked to two concentric torque shafts to which individual grips are attached. These grips serve the combined function of collective pitch stick grip and throttle controls. It is possible to adjust either throttle independently of the other, and, when the fuel flow is balanced equally between the engines, the throttles may be locked together to obtain thrust balance throughout the throttling range. The locking function is accomplished by a thumb-actuated, toggle latch at the end of the stick grip. An adjustable friction feature is provided to vary the friction required to turn the throttle grips. This adjustment is made by turning a third knob next to the collective stick box section. The coordination of throttle position and collective pitch on present XH-26 helicopters is strictly manual. The throttle is rotated, in the direction the fingers point, as the collective pitch control stick is raised. This is a natural and conventional motion, and little difficulty has been experienced by the pilot in becoming accustomed to the collective pitch and throttle adjustment coordination. In later aircraft, it is anticipated that an automatic-type throttle control will be incorporated to relieve the pilot of coordination requirement.

There is a dual fuel flowmeter in the instrument console which effectively serves as the thrust output indicator. Each flowmeter is color-coded to the throttle grip and particular engine so that the pilot can identify the engine that he is starting or controlling.

Power Plant

The pulse-jet engines delivered with XH-26 helicopters are American Helicopter AJ-7.5–1 engines.

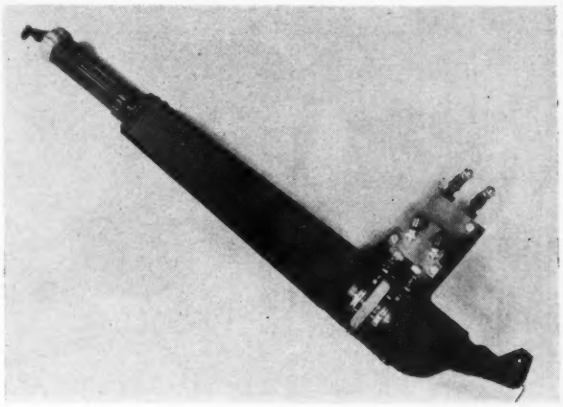

FIG. 11. Collective pitch stick—throttle installation.

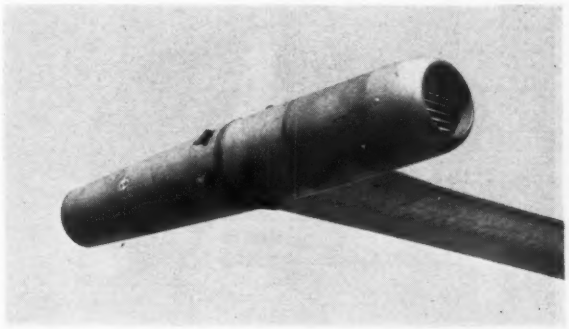

FIG. 12. AJ-7.5 rotor-tip installation.

These power plants are the result of considerable development effort directed toward obtaining reliable, high-performance, lightweight, and long-life rotary-wing, tip-mounted, pulse-jet engines. Fig. 12 shows the rotor-tip installation of an earlier model, AJ-7.5 pulse-jet engine.

The design problems presented in the development of pulse-jet engines suitable for rotary-wing, tip propulsion are (a) obtaining power plants that will produce a service life in excess of 100 hours without replacement of any part, (b) producing a high, useful propulsive power at a low specific fuel consumption in the tip speed range of 300–500 ft. per sec., and (c) achieving both of the foregoing objectives on the tip of the rotor blade which commits all components of the power plant to operate in a uniform gravitational field of 400 to 600 times the gravitational acceleration. All of these objectives have been achieved successfully in the AJ-7.5–1 power plant.

The power plant shown in Fig. 12, as with the AJ-7.5-1 engine (a) contains only one moving component, the inlet valve; (b) requires no lubrication; (c) can be removed by the removal of only two retention bolts and by disconnecting the fluid and electrical lines; (d) contains an integral, compressed-air starting system enabling positive, static starts and maximum rotor acceleration torque; and (e) is mounted to the rotor blade tip by means of a freely swiveling joint that tends to minimize rotor blade torsional moments and permit

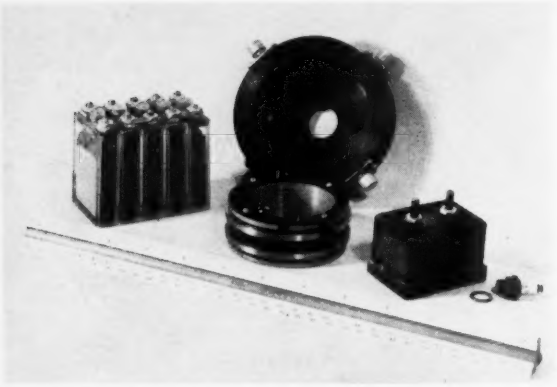

FIG. 13. Battery, slip rings, coil, spark plugs.

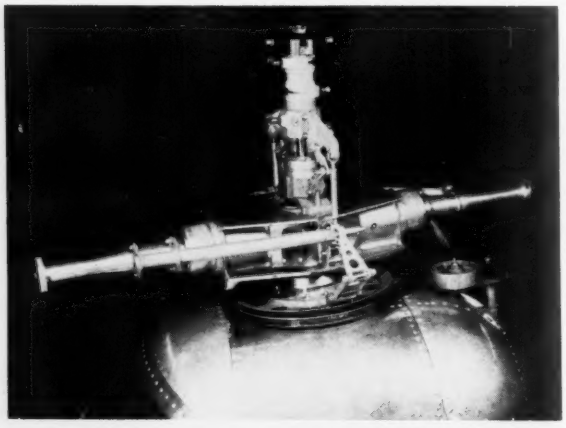

FIG. 14. Upper accessory system and rotor installation.

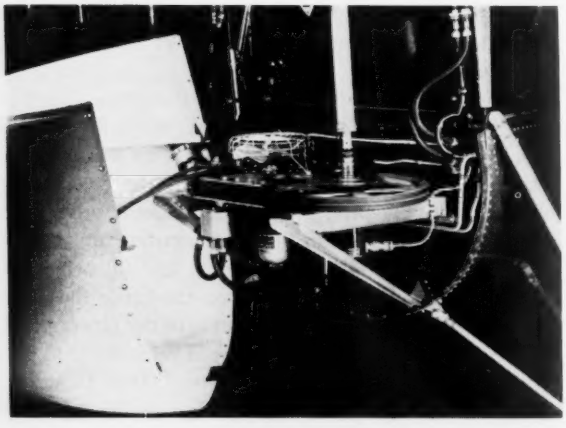

FIG. 15. Lower accessory system.

the power plant to align itself with the rotor tip path plane, under all flight conditions, so as to obtain maximum propulsive torque.

One of the most commonly asked questions concerning the pulse-jet rotor system is, "How do you get the fuel to the engines?" The *real* design problem is, once the fuel is transferred to the rotor system, how do you *keep* it from flooding out the engine! The fuel is contained in the lower fuselage in bladder-type fuel cells. It is pumped, by a rotor-driven pump, through the dual flowmeters and throttle valves to individual passages in the rotor shaft (see Fig. 8). The fuel then passes upward, through this fluted shaft into individual rotary seals contained in the rotor-hub system, into the fuel lines within each blade to the engines.

Starting fuel pressure is provided by an inert-gas-charged, bladder-type accumulator that is charged to the required operating pressure from the pump discharge during the rotor deceleration after shutdown. Similarly, the compressed air required for starting is provided by an air-storage bottle. This bottle is charged in flight by a three-stage air compressor driven by the accessory drive system. Ignition and compressed air are supplied to the engines only while a particular engine is being started. The ignition system, shown in Fig. 13, consists of a small, lightweight, 6–8 volt, rechargeable storage battery, switches, sliprings, ignition coils, and miniature spark plugs.

Accessory Drive System

The rotor-driven accessories of the XH-26 consist of the tachometer generator, fuel pump, air compressor, and directional control tail rotor. The accessory system of the Jet Jeep is interesting, from a design standpoint, in that *there are no gears utilized in the design.* Standard industrial "cog" V-belts are employed throughout to produce the proper increase in rotational speed and the required accessory power.

The power to drive these accessories is extracted from the main rotor by means of two scissors connected to the main pulley sheave. The scissor pickoff points are aligned with the teeter axis of the rotor so that variations in accessory power cannot affect the cyclic control system.

Fig. 14 shows the arrangement of the upper accessory drive system including the scissors, main sheave, belts, idler pulley, and driven sheave. Two V-belts are used to provide the required power. The idler pulley, located on the "slack side" of the belts, maintains the required belt tension and is readily adjusted, as required, for any belt wear or stretch. The driven shaft, supported from the aft, upper fuselage, is connected at its lower end to a universal joint that in turn drives a torque tube. The torque tube has a second universal joint at its base which has a keyed coupling to the lower accessory system to permit the upper fuselage to be folded. The lower accessory system, shown in Fig. 15, is readily accessible upon removal of the aft fuselage. The accessories are mounted to the lower side of the lower accessory system and are all driven by two V-belts connected to a series of sheaves of appropriate diameter to produce the required rotative speed. The tachometer generator is driven at the large sheave—i.e., torque tube, rotative speed of 5 times main rotor r.p.m. The fuel pump is driven by a smaller sheave at 11.65 times the main rotor r.p.m. The air compressor is driven by an idler pulley (in order to reverse the direction of rotation) at 16 times the main rotor

r.p.m. The tail rotor drive sheave is connected to the same shaft that drives the fuel pump. A single, long V-belt extends from the tail rotor drive sheave on the lower accessory system, through the aft fuselage, to a sheave on the tail rotor drive shaft. The tail rotor turns at 13.64 times the main rotor r.p.m. The lower accessory system belts are adjusted for tension and wear by means of an adjustable take-up on an idler sheave shown in Fig. 16. Tail rotor belt tension adjustment is accomplished by rotating the lower accessory system about its support point at the center of the large sheave.

The service experience with the belt-driven accessory system has proved it to be a highly reliable, serviceable, and potentially long-life system. The absence of gears and the use of standard commercial belts throughout has reduced the cost and, more important, eliminated the requirement for special tools and precision gear alignment procedures. Any "GI" who has ever had difficulty with the fanbelt on his own car or Jeep can readily diagnose and adjust for the infrequent slippage, belt wear, etc., which may occur in service. The only lubrication required in the entire aircraft is the periodic greasing of bearings and the compressor oil change.

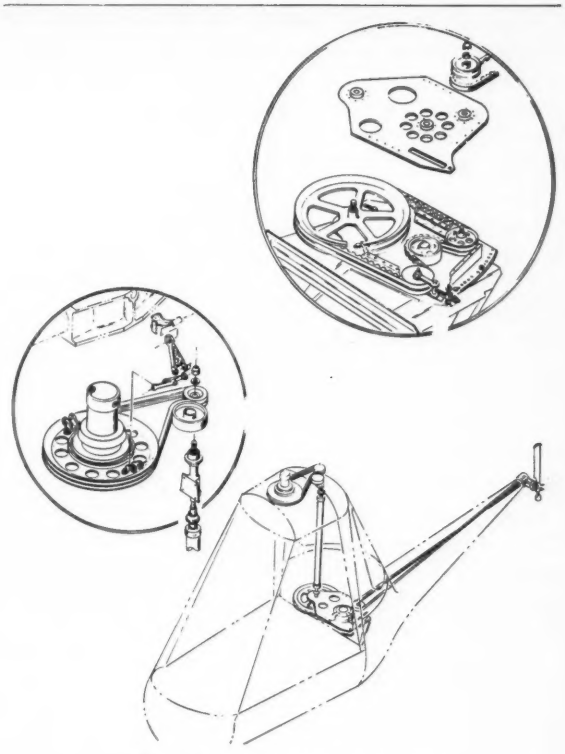

FIG. 16. Lower accessory system.

Interior Arrangement

The interior of the XH-26 is basically in accordance with the U.S. Army and Air Forces standard helicopter cockpit arrangement. The standard location, travel, and adjustments of all flight controls are incorporated. The instruments, radio, map case, and secondary controls, switches, etc., are all located in the centrally located instrument console, shown in Fig. 17. The pilot's seat is a fiberglass-reinforced plastic seat designed, according to Government specifications for a short-range seat, to accommodate a B-12 back-pack parachute. This seat weighs less than 5 lbs. and is designed to be as strong as the surrounding structure. A standard safety belt and shoulder harness are incorporated into the design.

The large doors provide easy access for entry into the cockpit and are jettisonable from the inside or outside in case of emergency. Maximum visibility in all directions is obtained in the Jet Jeep. The aircraft can be operated satisfactorily without the side doors, if desired.

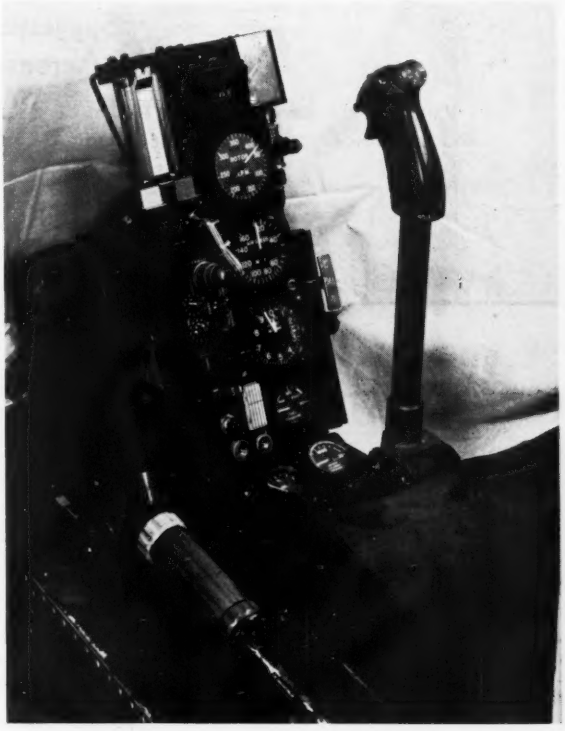

FIG. 17. Instrument console and cockpit arrangement.

Operational Features

Perhaps the most spectacular overall operational feature of the Jet Jeep is its ability to be *started and to get out of the take-off area in less than 30 sec.!* The instantaneous firefree starting of the tip-mounted, pulsejet engines with high rotor acceleration torque and no warmup period produce this amazing performance.

The pilot starts the engines by energizing a thumb-actuated ignition switch, depressing a foot-operated compressed-air valve, and opening the fuel throttle to the engine being started. The second engine is either started by a similar process as the rotor accelerates or can be "ram-air" started later by opening the second throttle and turning on the ignition.

The fuel system and pulse-jet engines are capable of satisfactory operation on almost any type of petroleum hydrocarbon fuel. The fuels that have been tested in the engines include kerosene, stove oil, diesel fuel, low-octane automotive gasoline, high-octane aviation gasoline, and a series of JP fuels.

Throughout the design of the XH-26, every effort has been made to obtain maximum simplicity and reliability. The elimination of all gears, oil lubrication, and cooling systems; ease of accessibility to all components for adjustments, repair, or maintenance; and ability to use Army Jeep tools for practically all normal maintenance (including recharging the battery from a Jeep battery) has resulted in an aircraft that possesses a maintenance-man-hour-to-flight-hour ratio that is approximately *the reciprocal* of values presently being obtained on conventional helicopters.

From a pilot's point of view, the operation of the XH-26 is one of feeling that "it fits." The cockpit controls, seat, and interior arrangement are comfortable and conventional. The aircraft "gets off like a scared rabbit"; is vibration-free in both the air frame and control system; can be flown, in forward flight, on only one engine; possesses a comparatively high degree of inherent stability; and is extremely maneuverable with very light, vibration-free movements of the controls.

Conclusions

The novel design features of the XH-26 Jet Jeep helicopter have been discussed in the foregoing paragraphs. This aircraft, designed and developed to meet all applicable military "Handbook" and specification requirements, is shown to be an extremely simple, functionally reliable, and relatively maintenance-free helicopter. Its rotor-tip propulsion, using American Helicopter Company, Inc., pulse-jet engines, eliminates many complex design and maintenance problems associated with other types of propulsion systems for helicopters. It is considered to be the first successful military-type jet-propelled helicopter and to have proved the feasibility of pulse-jet-propelled helicopters.

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Method for Measuring

Thrust in Flight on Afterburner-Equipped Airplanes

L. STEWART ROLLS* and C. DEWEY HAVILL*

Ames Aeronautical Laboratory, NACA

THE NEED of research and development flight-test groups for practical methods of measuring propulsive forces in flight has been greatly increased with the advent of high-power turbojet engines using afterburner thrust augmentation. The necessity of providing large amounts of cooling air for both air frame and engine has resulted in complex engine installations of the type wherein it is extremely difficult either to assess the actual performance of the installed engine or to investigate suspected performance losses caused by the cooling airflow without using detailed jet-exit mass-flow and momentum surveys. This paper will present an experimental technique that has been developed to determine the net propulsive force acting on an afterburner-equipped airplane in flight. This technique does not require the use of special high-temperature material.

A cross section of a typical jet-actuated ejector and fuselage exit is shown in Fig. 1. Here is shown the relative position of the fuselage outer surface with its protective shroud and the jet-engine tailpipe. For the ejector illustrated here, there is airflow between the shroud and the fuselage. In some aircraft the shroud and the fuselage are jointed at the end, and the amount of airflow in this area is small. In the case of an airplane with an afterburner, a method of changing tailpipe area must be included, and in this figure the eyelid type is illustrated. Normally, airplane performance has been based on either estimated or measured engine thrust in the primary system only. However, this procedure is not realistic if the use of large amounts of cooling air in the secondary system introduces appreciable thrust losses. To determine the actual thrust for performance or drag computation, it is necessary to measure the net propulsive thrust at the fuselage exit.

The desired net propulsive force can be defined as the gross thrust (i.e., the momentum of the exhaust gas at the fuselage exit plus any pressure force) minus the momentum of the air prior to its entering the airplane. In Fig. 2 are indicated the two conditions of interest in the determination of thrust in flight, the free stream and the jet exit. There are well-known instruments of sufficient accuracy available for the determination of free-stream conditions, so we will not consider these measurements in this paper. With knowledge of the conditions at the exit and at free stream, it is possible to determine the net propulsive force acting on the airplane.

As noted previously, the net thrust F_N is equal to the gross thrust F_G minus the ram drag or the initial momentum $W_a V_o/g$. With reference to Fig. 2 and the conditions listed for the fuselage exit, the equation for gross thrust for a unit area of fuselage exit is

$$F_G = \frac{2\gamma}{\gamma - 1} p_s \left[\left(\frac{p_T}{p_s} \right)^{(\gamma-1)/\gamma} - 1 \right] + (p_s - p_0)$$

In order to determine the ram drag quantity in the net-thrust equation, it is necessary to measure the total airflow at the fuselage exit. This is done by computing the total weight flow rate of the primary exhaust gas

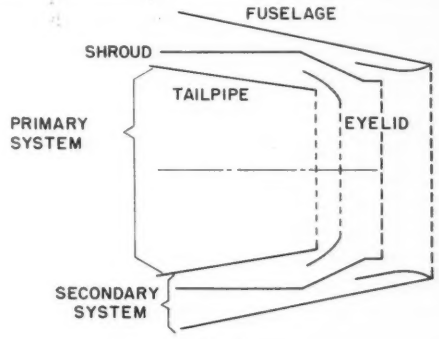
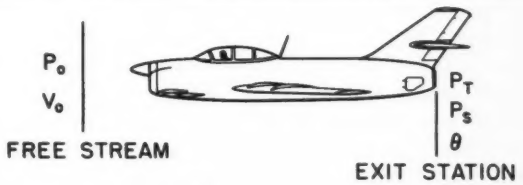


FIG. 1.



$$1\text{-}\quad F_N = F_G - \frac{W_a V_o}{g}$$

$$2\text{-}\quad \frac{F_G}{A} = \frac{2\gamma}{\gamma-1} P_s \left[\left(\frac{P_T}{P_s} \right)^{\frac{\gamma-1}{\gamma}} - 1 \right] + (P_s - P_o)$$

$$3\text{-}\quad \frac{W_a}{A} = \sqrt{\frac{2\gamma}{\gamma-1} \frac{g(P_s)^2}{R\theta} \left[\left(\frac{P_T}{P_s} \right)^{\frac{\gamma-1}{\gamma}} - 1 \right]}$$

FIG. 2.

Presented at the Propulsion Session, Annual Summer Meeting, IAS, Los Angeles, July 15–17, 1953.

* Aeronautical Research Scientist, Flight Research Branch.

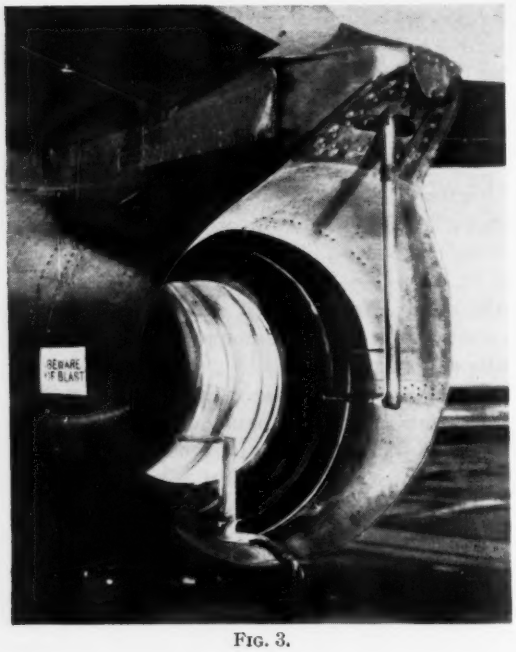


FIG. 3.

plus cooling air using measured values of local static and total pressures and local stagnation temperature. It is then assumed that this weight flow is equal to total airflow, which is equivalent to neglecting the weight of fuel in the primary stream. The airflow can then be computed using the following equation, based on a unit area:

$$W_a = \sqrt{\frac{2\gamma}{\gamma - 1}\frac{g(p_s)^2}{R\theta}\left[\left(\frac{p_T}{p_s}\right)^{(\gamma-1)/\gamma} - 1\right]}$$

Thus, it can be seen from these equations that, if the variation of total pressure, static pressure, and stagnation temperature across the fuselage exit is known or can be measured, it is possible to determine the net propulsive force of an airplane with a complex engine and fuselage cooling installation.

One method of measuring the variation of total and static pressures and stagnation temperature across the fuselage exit, which is in use at Ames Aeronautical Laboratory of the NACA, is shown in Fig. 3—that is, a power-operated swinging pitot-static-pressure and total-temperature probe. There also can be seen in this photograph a fixed air-cooled total-pressure probe that will be discussed later. The reason for using the swinging pitot-static-pressure and temperature probe in place of the more conventional fixed rake was the very high temperature, approximately 3,500° R., which is encountered during afterburner operation. There have been several instances where air-cooled total-pressure rakes have been mounted successfully in an afterburner tailpipe. However, for this installation where the static-pressure and stagnation-temperature measurements were required, the air-cooled rake was unsatisfactory due to difficulties of cooling the static-pressure probes that had to be placed on the rake and of converting the temperature of an air-cooled part to the temperature of the jet. Most aircraft that have afterburners usually require the additional thrust from these devices during the take-off condition, thus, one is not able to measure the thrust conditions with the afterburner off without supplying measuring equipment capable of withstanding the afterburner temperatures.

The exploded view of the swinging-probe installation presented in Fig. 4 shows the relative location of the probe actuating motor and supporting bearings. Although the swinging probe was originally air cooled, it was found that the probe was not in the exhaust stream long enough to require cooling. The speed of the actuator motor that moves the probe was adjusted so that the time required to traverse the jet was approximately 4 sec. The pitot-static-pressure probe was calibrated in the Ames 2- by 2-ft. transonic test equipment. The results of this calibration indicate that for the majority of the test runs the static-pressure

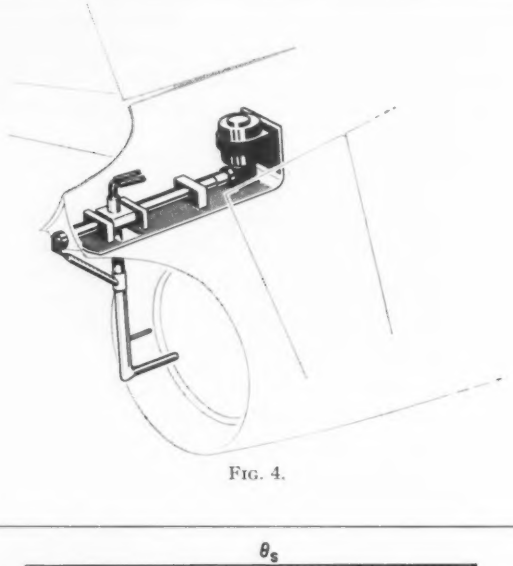
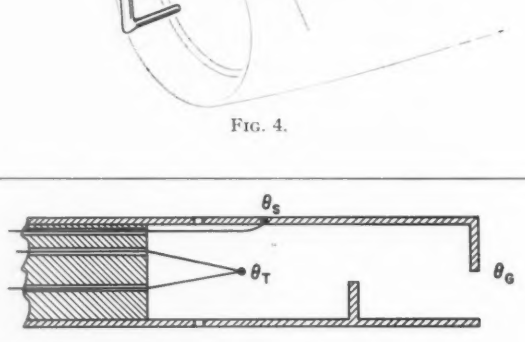


FIG. 4.



$\theta_G - \theta_T \sim$ ENERGY LOSS

ENERGY LOSS = ENERGY INCREASE OF SHIELD

ENERGY INCREASE OF SHIELD $\sim \dot{\theta}_s$

$\therefore\ \theta_G - \theta_T \sim \dot{\theta}_s$

HENCE $\theta_G = \frac{K\dot{\theta}_s}{P_s} + \theta_T$

FIG. 5.

error, due to blocking on the static orifices, could be neglected.

The differential-pressure transmitters used were Statham's Model P22A that has a range of ±5 lbs. per sq. in. A total-pressure tube was mounted atop the vertical fin of the airplane to supply a reference pressure from these total- and static-pressure transmitters. This reference pressure was recorded by a 0 to 15 lbs. per sq. in. absolute-pressure transmitter. The transmitters for the swinging probe were mounted close to the probe so as to minimize the time lag in the tubing system. The time-lag constants for the pressure system are 0.01 sec. for the static pressure and 0.025 sec. for the total pressures. The concept of the time-lag constant is explained in NACA TN 1605. The probe position transducer used was a Heliopot Model G. A total of approximately 450 traverses of the jet have been made with this probe, of which approximately 60 were made with the afterburner operating. The probe does not show any ill effects from the hot exhaust gas.

To determine the rate of airflow through the ejector system, it is necessary to know the variation of static temperature across the fuselage exit. The local static temperature can be obtained from measurements of the local stagnation temperature and local total and static pressures.

To determine the local stagnation temperature, a Chromel-Alumel thermocouple was mounted on the vertical member of the swinging probe. The details of this thermocouple are shown in Fig. 5. The instrument as used consisted of a single shielded thermocouple with a thermocouple in the shield. The lead-in wires for the thermocouple were made 50 diameters long to minimize conduction losses, and barriers were placed in front of the thermocouple which allow jet gases to enter but do not allow direct radiation from the jet to the thermocouple. These two thermocouple outputs were recorded by rapid-acting self-balancing potentiometers. The time constant for the recording systems was 0.03 sec.

In order to determine the steady-state temperature in the tailpipe from the temperature measured by the swinging probe, a series of calibration runs was made. It was assumed that the time constant of the primary thermocouple was short enough so that the output of this thermocouple gave a true indication of the temperature in its vicinity—that is, inside the shield. If this assumption is correct, then the difference between the thermocouple-measured temperature and the temperature of the entering gas would be proportional to the energy loss of the entering gas to the thermocouple shield, or

$$\theta_G - \theta_T = K \text{ (energy loss/mass-flow rate)}$$

The energy loss of the exhaust gas would be equal to the gain in energy of the thermocouple shield. This gain in energy of the shield is proportional to the rate of temperature increase of the thermocouple shield. The energy changes were equated, and the following equation for the temperature difference as a function of the rate of temperature increase was obtained:

$$\theta_G - \theta_T = K \text{ } (\dot{\theta}_s/\text{mass-flow rate})$$

The results of the calibration of the thermocouple installation indicated that the temperature difference was inversely proportional to the static pressure rather than mass-flow rate into the shield. When the flow became critical—that is, when $M = 1.10$—or pressure ratio reached critical value, a value of the total pressure divided by 1.86 was used for the static pressure. Thus the equation for relating the two thermocouple outputs as derived from the calibration procedure was

$$\theta_{\text{gas}} = (K\dot{\theta} \text{ shield}/p_s) + \theta_{\text{thermocouple}}$$

Following the experimental determination of the inverse proportionality of the temperature to the static pressure, a reason for its inclusion was sought. It was reasoned that the $\dot{\theta}_{\text{shield}}$ to be used in the equation should be the rate of change of the mean temperature of the shield ahead of the primary thermocouple; whereas, in this installation, the shield thermocouple was in the same cross section as the primary thermocouple. Thus, it was necessary to establish a relationship between the mean shield temperature and the measured shield temperature. To establish this relationship, two general effects were felt to be important. First, for higher gas velocities a relatively greater amount of heat transfer should occur at the shield baffles. This would result in a greater difference between the rate of temperature increase for the mean shield than for the measured. Second, for higher static gas temperatures a relatively greater amount of heat transfer would occur externally, and, since this transfer will be nearly the same for all longitudinal stations, the difference between the mean and the measured rates of temperature change will be lower. The simplest relationship between the mean rate of temperature change and the measured rate of temperature change is

$$\dot{\theta}_s'/\dot{\theta}_s = K'(V/\theta_{\text{static}})$$

By substitution of this relationship into the equation for energy increase, the final form of the equation is obtained as before

$$\theta_{\text{gas}} = (K\dot{\theta}_{\text{shield}}/p_s) + \theta_{\text{thermocouple}}$$

where the value for K was determined to be 2,080 for θ in °R. and p in pounds per square foot.

The measuring equipment having been discussed, possible applications and some typical test results will be reviewed. The actual net propulsive force, as determined by the swinging probe, is necessary to determine the realistic value of airplane drag, as values determined from engine thrust alone include thrust losses in the ejector as drag. The values of gross thrust, net thrust, and total airflow determined at the fuselage exit can be compared with these values for the bare engine to determine the efficiency of the ejector configuration.

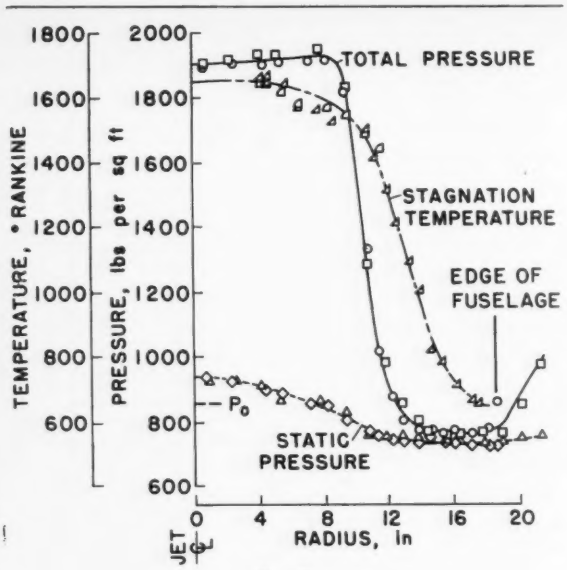


FIG. 6.

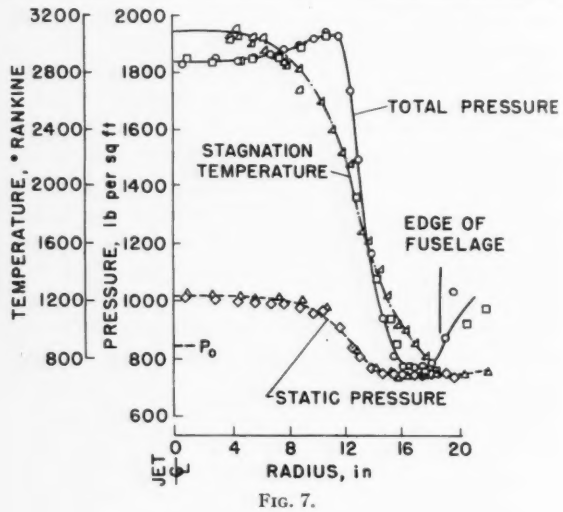


FIG. 7.

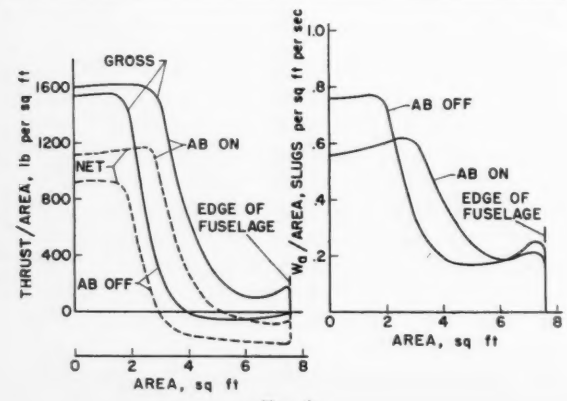


FIG. 8.

A typical set of data obtained during flight tests of an afterburner-equipped airplane are presented in Fig. 6. These data are for nonafterburner operation. The variations of total pressure, static pressure, and stagnation temperature are shown as a function of radial location at the fuselage exit. It was assumed that for the circular exit of this tailpipe, the conditions around any radius would be equal; thus, the conditions measured across one diameter could be applied to the exit area. The data in Fig. 6 were obtained during a complete traverse of the jet; however, in the figure the curves have been folded about the jet centerline. The difference between the left and right sides of the jet indicates the lag effect and amount of uncertainty in the data which is seen to be small. The free-stream static pressure is also shown in the figure as a reference. Fig. 7 shows the variation of total pressure, static pressure, and stagnation temperature as a function of radial position for afterburner-on operation. Comparison of these data with those in the previous figure shows the increased primary jet area with, consequently, a smaller cooling airflow area and the increased temperature during afterburner operation.

By use of the equations listed earlier in this paper, these profiles have been used to compute the local gross-thrust, net-thrust, and airflow variations across the fuselage exit. These results are presented in Fig. 8. The total gross and net propulsive force and total weight of airflow can be determined by integrating the curves shown in Fig. 8 over the total area of the fuselage exit. During this investigation, since the main interest was the conditions in the primary and secondary systems, the area used for the integration was the fuselage exit area. The characteristics of the ejector as measured with this equipment, insofar as total airflow and gross thrust are concerned, agree well with tests of an ideal ejector, of these proportions, made at Lewis Flight Propulsion Laboratory.

It is of interest after determining the total thrust of the engine-ejector combination to compare this thrust with the primary thrust for this engine. This comparison gives an indication of the efficiency of the jet-actuated ejector. The engine thrust was determined during the investigation at Ames Aeronautical Laboratory with a fixed, air-cooled, total-pressure probe. Since this probe is in the exhaust continuously, it is cooled by air bled from the engine compressor. For this purpose, a line $1^1/_2$ in. in diameter was connected to the cockpit pressurizing and refrigerating system. The average life for a fixed probe was about 8 hours including approximately 1 hour during afterburner operation. These probes are sprayed with aluminum under oxidizing conditions such that approximately 25 per cent of the coating is aluminum oxide. The aluminum-oxide coating has prolonged the life of these fixed probes by a factor of approximately one-third.

For the specific case of the primary system, it is possible to simplify the gross-thrust equations to

$$\frac{F_a}{A_{p_0}} = \frac{2\gamma}{\gamma - 1}\left[\left(\frac{p_T}{p_s}\right)^{(\gamma-1)/\gamma} - 1\right]$$

$$\text{for } \frac{p_T}{p_0} < \left(\frac{\gamma + 1}{2}\right)^{\gamma/(\gamma-1)}$$

$$= \frac{2p_T}{p_0}\left[\left(\frac{2}{\gamma + 1}\right)^{\gamma/(\gamma-1)}\right] - 1$$

$$\text{for } \frac{p_T}{p_0} > \left(\frac{\gamma + 1}{2}\right)^{\gamma/(\gamma-1)}$$

In these equations it is assumed that there is a uniform distribution of pressure across the tailpipe and that the static pressure in a nonchoked case is equal to free-stream static pressure. To compute the net thrust produced by the primary jet, it is necessary to know the engine airflow rate. Three available methods are: (1) computation from engine operating conditions and engine manufacturer's data on the compressor, (2) computation from measured tailpipe total and static pressures and temperature, and (3) measurement of the airflow rate at the engine air inlets. The first two methods have been used in investigations at Ames Aeronautical Laboratory.

With the techniques for measuring thrust as presented in this paper, a set of ejector characteristics has been calculated. By the use of the afterburner on run discussed earlier, the ejector characteristics were as follows: a gross-thrust ratio (the ratio of gross thrust of the ejector to gross thrust of the tailpipe) of 1.06 and net-thrust ratio (the ratio of net-thrust ejector to net thrust of the tailpipe) of 0.83.

The method of determining the net propulsive force on an afterburner-equipped airplane as presented in the paper has been used successfully to determine the net and gross thrust and total airflow rates in flight. The scatter of the data and comparison of the data from the swinging probe with a limited amount of fixed-rake data with the afterburner off indicate an overall accuracy in the determination of net thrust of about 5 per cent. The ejector characteristics as determined by the swinging-probe technique have checked favorably with the characteristics of a similar ejector as determined during ground evaluation of ideal ejectors.

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Starting Loads in Supersonic Wind Tunnels

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North American Aviation, Inc.

Abstract

A technique of wind-tunnel operation is discussed which results in a considerable reduction of the shock loads on sting-mounted models during the starting and stopping periods of the wind tunnel. The technique consists of a two-step opening and closing of the upstream valve located between the reservoir and the test section. Partial opening of the valve during the periods of unsteady flow reduces the density of the air in the test section and consequently the shock loads on the model.

It is shown that the technique is most effective at higher Mach Numbers where the shock loads are normally large. The reduction of the loads at lower Mach Numbers is limited by the fact that the wind tunnel cannot be started if the upstream valve opening is restricted below a critical value. It is also shown that a compromise with respect to running time may be necessary to obtain the benefit of the valve opening technique during the stopping period of the wind tunnel.

Introduction

Supersonic wind tunnels are started by opening valves upstream and downstream of the test section through which the high-pressure air in the reservoir flows into the low-pressure region downstream of the test section. The starting period is the time elapsed between the opening of the valves and the establishment of steady supersonic flow in the test section. The length of the starting period depends on the type of the wind tunnel and on the design of the valves. The 16- by 16-in. supersonic wind tunnel of North American Aviation, Inc. (Fig. 1) is a nonreturn, blowdown tunnel using dry air at atmospheric pressure stored in a vented tank with a capacity of 22,500 cu.ft. The low pressure at the downstream side is obtained by evacuating a sphere with a volume of 36,000 cu.ft.

To start the wind tunnel, first the upstream valve is opened (see Fig. 1), immediately followed by the downstream valve. The downstream valve is of a specially designed, quick-acting type that allows the establishment of steady flow in the test section in 1.2 sec. During this short period the "tunnel shock" passes through the test section, causing shock loads on the model which are much larger than the normal loads measured in the steady flow field. The same conditions are obtained when the tunnel shock is traveling back upstream at the end of the run. The occurrence of the shock loads results in a grave problem for the designer of models and balances. An undesirable compromise is often necessary to meet the requirements for measuring small normal loads with great accuracy and, at the same time, meet the requirement of a balance and a model mount sufficiently strong to carry the large shock loads during the starting and stopping periods of the wind tunnel.

* Specialist, Aerodynamics.

Experimental Technique

To find a solution for this problem, a small research program was carried out in the 16- by 16-in. supersonic wind tunnel using sting-mounted models carried on a three-component internal balance. This balance measures forward-and-aft normal loads and chord force. The power input to the strain gages of the balance (5 volts, a.c.) was supplied by the same unit that amplified the output of the gages so that it could be recorded with sufficient amplitude on an oscillograph recorder.

Test Results

It was found that during the tunnel starting period the model was set in a violent periodic motion, a motion that failed to be damped out before the end of the run. The pulse of the passing tunnel shock evidently caused the model to vibrate in its natural frequencies. For the case of the models used in this test, the period of the movement in streamwise direction was of the order of 300 cycles per sec., and the period of the movement in a direction perpendicular to the stream was of the order of 30 cycles per sec. In the first stage of the starting process, the model is subjected to a rapidly changing pressure distribution even before the tunnel shock reaches the test section, and the peak of the load caused by the passing shock is a function not only of the pressure difference across the shock but also of the attitude and direction of movement of the model at the instant the shock reaches the test section.

For the same Mach Number and the same angle of attack, the recorded peak load for different runs may therefore vary within rather wide limits. It may be expected that under these conditions the relations between peak shock loads, Mach Number, and angle of attack for a model do not show up as well-defined continuous curves unless a large number of runs is made and aver-

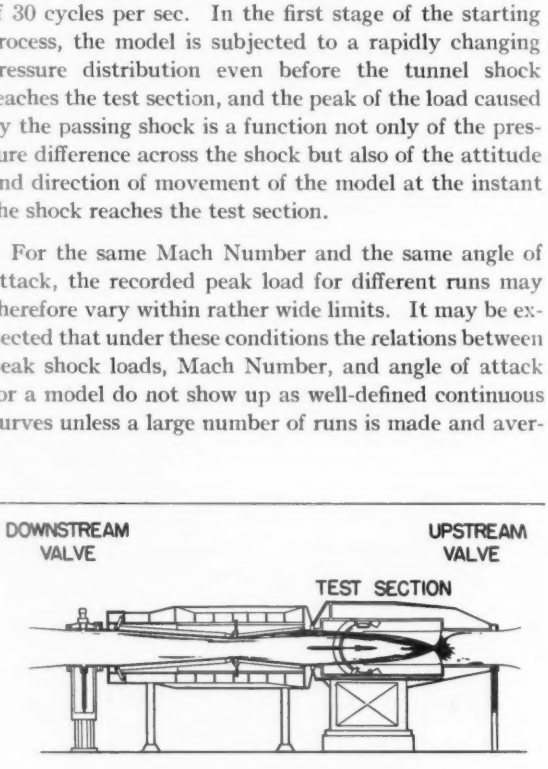


FIG. 1 NORTH AMERICAN AVIATION, INC. 16" X 16" SUPERSONIC WINDTUNNEL (SCHEMATIC)

age peak loads determined. With these restrictions in mind, it may be stated that the peak shock loads increase considerably with Mach Number. For a cylindrical model with a conical tip, it was found that the peak shock loads are almost independent of angle of attack up to $\alpha = 8°$. For airplane models it would seem that there should be a pronounced influence of α on the peak shock loads.

The vibration of the model, excited in its natural frequencies, is the cause of a possible source of error even in the determination of the normal operating loads. In the regular wind-tunnel tests, the power input to the strain gages of the balance is 6 volts, d.c., and the recording apparatus consists of Leeds & Northrup speedomaxes. The unsteady loads on the model result in rough traces on the recording instruments, which are not able to follow the rapid changes in the output of the strain gages. Averaging the deflection by visual estimate is by no means equivalent to the time integral of the output of the strain gages. This difficulty of recording the true load may easily be overcome by the use of narrow band filters, eliminating the basic cycles of 30 cycles per sec. and 300 cycles per sec.

To minimize the mechanical effects of the shock loads on the balance and the sting-mounted model, it has been proposed to open the upstream valve in two steps during the starting period. Partly opening the upstream valve until the shock has passed the test section reduces the mass flow during the starting period and therefore the density of the air in the test section, resulting in lower shock loads on the model. After the shock has passed, the valve can be opened entirely to allow normal operation at the highest possible Reynolds Number.

The test results show that the shock loads can be reduced materially by restriction of the opening of the upstream valve (Fig. 2). At higher Mach Numbers the effect is extremely pronounced. At lower Mach Numbers the reduction of the starting loads is limited by the fact that the tunnel will not start if the channel upstream of the nozzle throat is restricted. The peak loads at the lower Mach Numbers, however, are much smaller than the corresponding loads at the higher Mach Numbers, and it is possible to keep the starting loads virtually a constant and equal to the loads at the lower end of the Mach Number range by proper adjustment of the upstream valve opening (Fig. 3).

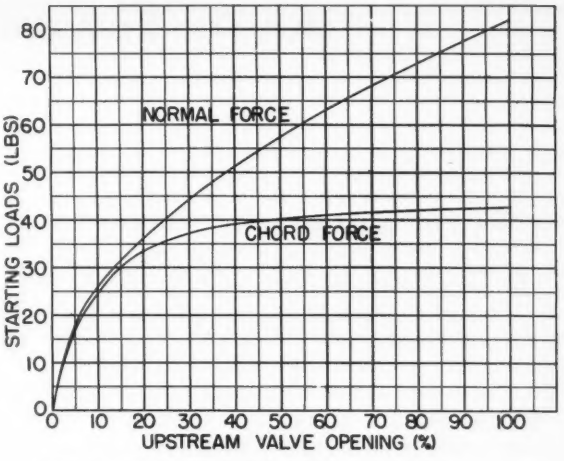


FIG. 2 PEAK STARTING LOADS AT M=3.26

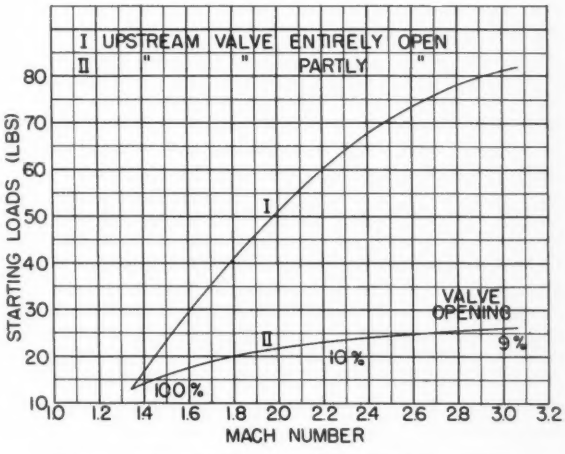


FIG. 3 PEAK STARTING LOADS (NORMAL FORCE)

Conclusions

The success of this method for reduction of the starting loads depends on the ability to operate at a sufficiently low air density in the test section during the starting period. The stopping loads are of the same order of magnitude, and, if a long run is made at high Mach Number, the pressure in the vacuum sphere increases to an extent that may make the partial closing of the upstream valve ineffectual in reducing the stopping loads to the required level. A compromise in length of wind-tunnel run may be necessary to provide the proper load reduction during the stopping period.

An Air-Powered Servo-Actuator

RALPH KRESS*

Solar Aircraft Company

THIS PAPER DESCRIBES a linear servo-actuator designed for afterburner variable nozzle actuation. Turbojet compressor discharge air is utilized as a source of energy for powering this new device. The maximum input signal force required is approximately 5 lbs., while the output force can be as high as 10,000 lbs. Pure servo action is achieved by means of integral self-contained hydraulic system. The actuator is designed to operate in an ambient temperature of 400°F. without cooling. Design details are presented, together with photographs and some performance data. Potential applications other than afterburner nozzle actuation are discussed.

The design of any component for present-day high-speed jet aircraft presents many problems. Primarily, of course, the device must work; and, secondarily, it must work well. Once a device has proved that it works, the designer is faced with future changes and choices, all tending to improve it and its functional operation.

A good example of this may be found in the design of an afterburner for a modern high-performance jet engine.

Early work dealing with afterburners was primarily concerned with obtaining stable combustion and performance. The development engineer's time was, therefore spent on the burner problem, and, because of this, early afterburners were as simple as possible to alleviate the high-temperature problems associated with near-stoichiometric burning.

Nozzles for these afterburners were of the clamshell type and had only two positions, either fully open or fully closed. The required actuator was, therefore, adjustable to only two positions.

The advent of the variable-thrust afterburner, with its fully variable-area nozzle, made necessary an actuator that was infinitely adjustable from fully open to fully closed and capable of locking at any point in this range. Greater power was a prime requisite of the fully variable actuator, because, unlike the balanced clamshell nozzle, the variable flap-type nozzles are aerodynamically unbalanced, and, in operating them, the actuator must overcome both friction and the internal gas pressures acting on the nozzle flaps.

Actuators in general can use any of a number of sources of power. In an airplane and on a jet engine, actuators are limited to four practical sources of energy. These are: electricity, hydraulic pressure, lubricating oil pressure, and pneumatic pressure. Each has its advantages and disadvantages, none of these being ideal.

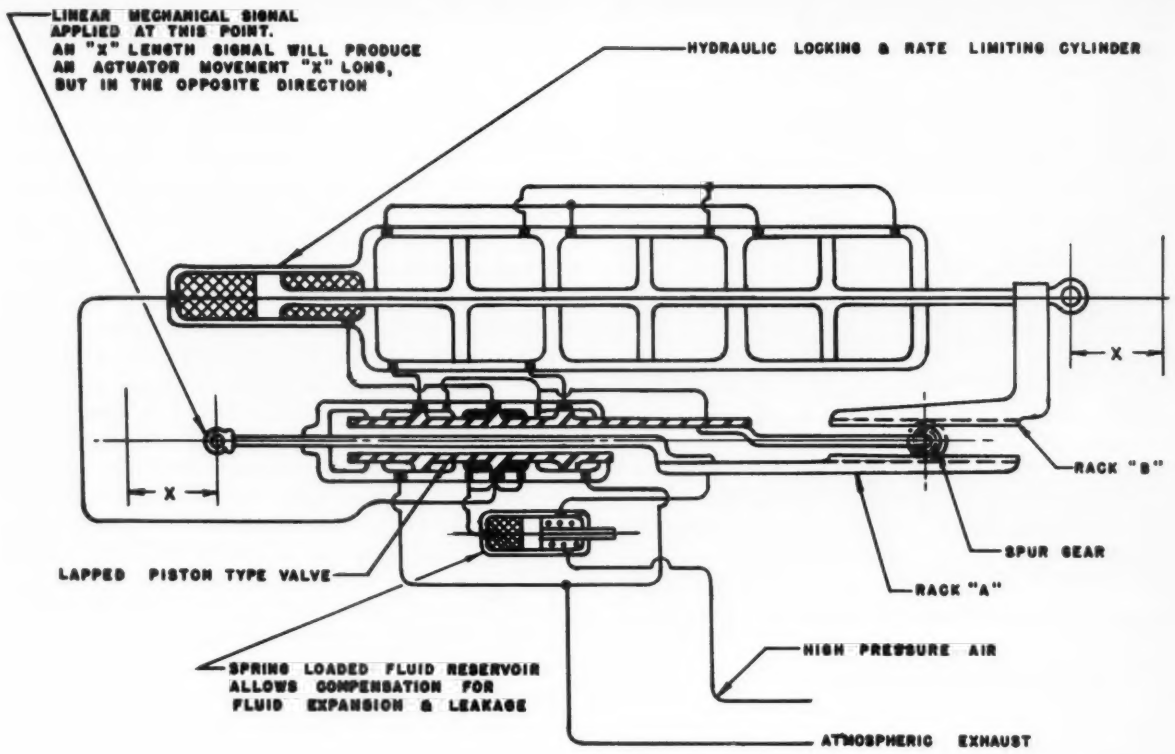
An electrical actuator is a natural choice for an afterburner. Electrical Actuators have been made for many years in all shapes and sizes and for a variety of operating conditions. Electrical energy is readily available on all aircraft and is easy to control. Electrical actuators are easily designed into electronic control systems. By necessity, however, the actuator must be placed near the variable nozzle, and, because of the high ambient temperature found in this area, the electrical actuator requires a complicated cooling means. The power requirements of flap-type nozzles are from 3 hp. and up. This is probably the most serious argument against electrical actuators. Actuators of this power are not flyweights. Because aircraft designers are extremely weight conscious, the electrical actuator has been limited more or less to the balanced-type clamshell nozzle.

Most modern aircraft are equipped with hydraulic systems and require a hydraulic pump on the engine. A few of the jet engines themselves are equipped with integral hydraulic systems, in addition to the aircraft system for air inlet screen and no-burning nozzle actuators. All jet engines are equipped with pressure lubricating systems. Any of these are sources of energy for afterburner nozzle actuation. Hydraulic systems are high-pressure systems and, therefore, can provide high actuating forces with small actuators of light weight. Actuators using lubricating oil pressure can produce limited forces because of the relatively low pressure available. The lightweight advantages of hydraulic systems make them attractive for nozzle actuation; however, they do have certain disadvantages. Particular care must be used in all joints and packing design because of the fire hazard. All lines and devices subject to leakage must be kept clear of the hot jet afterburner surfaces. The high ambient operating temperature of the jet engine is a serious problem in the operation of many types of control valves used in conjunction with the hydraulic actuator. The hydraulic fluid itself could boil or decompose under high temperatures. With the new high-temperature hydraulic fluids, this problem may be alleviated.

All gas-turbine engines possess a source of power which can be useful for driving auxiliaries. Relatively high-pressure air may be tapped off the compressor section of the engine and used as a source of power for accessories. Quite a bit of air may be used before serious loss of power is noted in the jet engine. Compressor discharge air is attractive as a power source for actuators for many reasons:

Presented at the San Diego Section Meeting, IAS, August 20, 1953.

* Design Engineer, Development Engineering Division.


LINEAR MECHANICAL SIGNAL APPLIED AT THIS POINT. AN "X" LENGTH SIGNAL WILL PRODUCE AN ACTUATOR MOVEMENT "X" LONG, BUT IN THE OPPOSITE DIRECTION
HYDRAULIC LOCKING & RATE LIMITING CYLINDER
X
X
RACK "B"
SPUR GEAR
RACK "A"
LAPPED PISTON TYPE VALVE
SPRING LOADED FLUID RESERVOIR ALLOWS COMPENSATION FOR FLUID EXPANSION & LEAKAGE
HIGH PRESSURE AIR
ATMOSPHERIC EXHAUST

SCHEMATIC DIAGRAM
PNEUMATIC SERVO ACTUATOR

FIGURE 1

(1) The air is always available for use as long as the engine is running.

(2) The exhaust air may be dumped almost anywhere and not do any harm.

(3) Air constitutes a one-line system—that is, no reservoir or fluid return lines are necessary.

(4) It is unaffected to any great extent by high temperature.

(5) The design of packings and seals could be relatively simple, since leakage would introduce no safety problems.

(6) Air, being a compressible fluid, is a source of potential energy. It may therefore be used not only to transmit energy but also to store it.

The disadvantages of the use of air, although serious, can be circumvented as follows:

(1) The available compressor discharge pressure on most jet engines is relatively low in comparison to a standard hydraulic system. This available pressure is also a function of altitude and air speed.

(2) The ability of air to compress and store energy is also a disadvantage. The fact that air compresses means that it acts similarly to a spring and, when used in actuating cylinders, results in springy or bouncing action of the piston. Positioning of the piston, as known in hydraulic servo cylinders, is extremely difficult to accomplish.

A method of stabilizing an air cylinder, which makes it fully positionable and in all respects makes it act like a hydraulic cylinder, has been worked out. This design incorporates an integral sealed self-contained hydraulic system within the actuator. An actuator of this type has been designed by Solar Aircraft Company and proved practicable.

Fig. 1 is a diagrammatic sketch showing the basic operating principle of the actuator. It consists of an assembly of the following commonly understood components:

(1) A pneumatic cylinder supplying the prime actuating force of the actuator.

(2) A hydraulic cylinder functioning to limit the rate of the air cylinder and also to lock it.

(3) A six-way variable valve that simultaneously meters air to the air cylinder and hydraulic fluid to and from the hydraulic cylinder.

(4) A rack and pinion differential that computes the difference between the input signal and output and adjusts the metering valve accordingly.

(5) A spring load fluid reservoir that allows for fluid expansion during operation and fluid leakage.

The actual sequence of operations is as follows:

(1) A control signal, consisting of a linear mechanical motion whose linear velocity is proportional to the

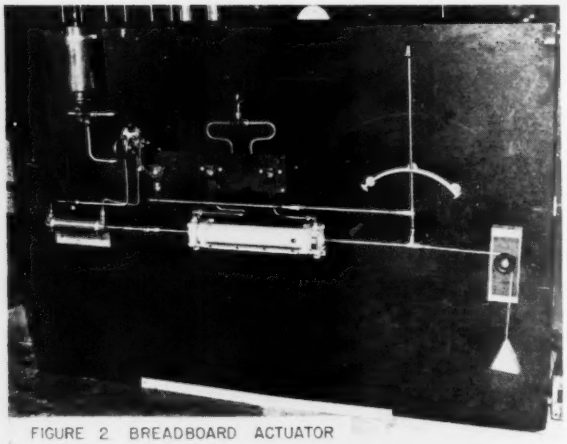


FIGURE 2 BREADBOARD ACTUATOR

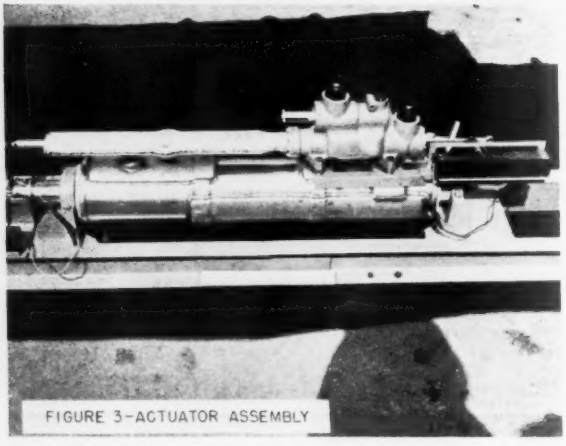


FIGURE 3-ACTUATOR ASSEMBLY

required actuator linear displacement, arrives at the actuator control valve.

(2) The signal moves Rack "A" relative to fixed Rack "B," thereby displacing spur gear and attached valve piston relative to valve body and actuating cylinder.

(3) Piston valve admits high-pressure air to proper side of power piston and exhausts air on opposite side of piston. Piston valve also opens hydraulic line and allows variable restricted fluid flow from one side to opposite side of hydraulic locking piston.

(4) Under air pressure differential, air piston, Rack "B," gear and piston valve move until original relationship between valve piston and valve ports is restored. Hydraulic circuit also closes, locking hydraulic cylinder line preventing air cylinder overtravel and springy action due to compressibility of air.

Before starting on the final design of the actuator, a breadboard model was made to prove the basic principles. Fig. 2 is a photograph of the completed breadboard actuator. The pneumatic section was completely separated from the hydraulic section in order to isolate any unforeseen conditions that might prevail in this preliminary study. The combined air and hydraulic valve was made up of three standard two-way plug valves linked together. Two of these acted as a four-way valve for the air cylinder, while the third controlled the hydraulic cylinder. The air cylinder and hydraulic cylinder were tied together with a quick-disconnect link, in order that the stability of the system might be checked both with, and without, the hydraulic damping circuit. The feedback circuit was handled by a linkage rather than a gear train and the input signal was entered at this linkage through the handle shown. The unit was loaded by means of a weight pulley and cable tied directly to the air cylinder.

In testing the breadboard unit, it was discovered that the air system alone was relatively stable, the output positioning itself within three complete cycles. Much overshoot was noted on high input signals. After stabilizing, however, any change in load would immediately make the system start to hunt, with gradual stabilization under the new load. Upon cutting in the hydraulic system, an immediate change in the operating conditions was noted. At high input signals, the system approached stabilization with almost no overshoot and with undetectable hunting. Changes in loading up to the limits of the hydraulic system produced no discernible changes in the position of the system. The recovery rate of the output at high input signals was noted to increase as the loading approached the capacity of the system.

On the basis of the limited testing performed on the breadboard model, it was decided that the basic idea of the actuator was good and that it was feasible to make a full-scale working unit. Accordingly, design calculations and preliminary layouts were initiated.

Fig. 3 is a photograph of the finished final design actuator. The final specifications for this particular actuator were set by its application. In this case, it was to be used on an afterburner mounted off the afterburner skin. It was to be separated from the afterburner by a cooling shroud that left an ambient temperature in the aft engine cavity of about 400°F. Since it was desired to do the job with no additional cooling for the actuator, 400°F. was to be the actuator design ambient temperature. The determining factor for the air cylinder's size did not turn out to be the condition requiring the highest actuating force. The high-altitude operation determined the actual cylinder size because of the low compressor discharge pressure available at this flight condition. Under the highest compressor discharge pressure available from the engine, this actuator could deliver approximately 10,500 lbs. of actuating force.

The power section (Fig. 4) of the actuator consists of three air cylinders connected in series, having a common piston rod and outer barrel. This arrangement was decided upon in order to keep the outside diameter of the actuator to a minimum. Weightwise, it would probably have been more efficient to achieve the desired area with one piston, but the space requirements in the airplane were too critical to allow this. The outer barrel consists of a steel shell of 6.25 in. inside diameter. Stamped manifolds are welded to the shell to direct the air to the various chambers, and grooves are machined

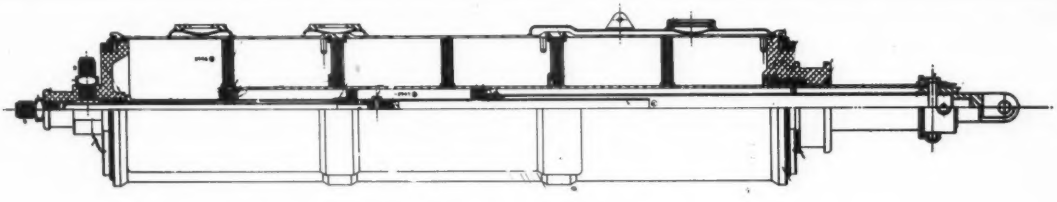
in to accommodate assembly snap rings. The bore is hard chrome plated and honed to approximately a 5 RMS finish.

Pistons and separators are machined discs of 24 ST aluminum alloy. The separators contain silicone O-rings for sealing the chambers and are retained in the barrel by snap rings. The main piston rod passes through the separators and is backed up by an Inconel compression ring that keeps the sealing ring in contact with the piston rod. The pistons are retained on the piston rod by snap rings and are sealed at this point by a silicone O-ring. The piston ring was of carbon-graphite material and consists of three lap-jointed square cross-section segments. The piston ring is backed up by an Inconel compression ring that keeps it in contact with the cylinder walls.

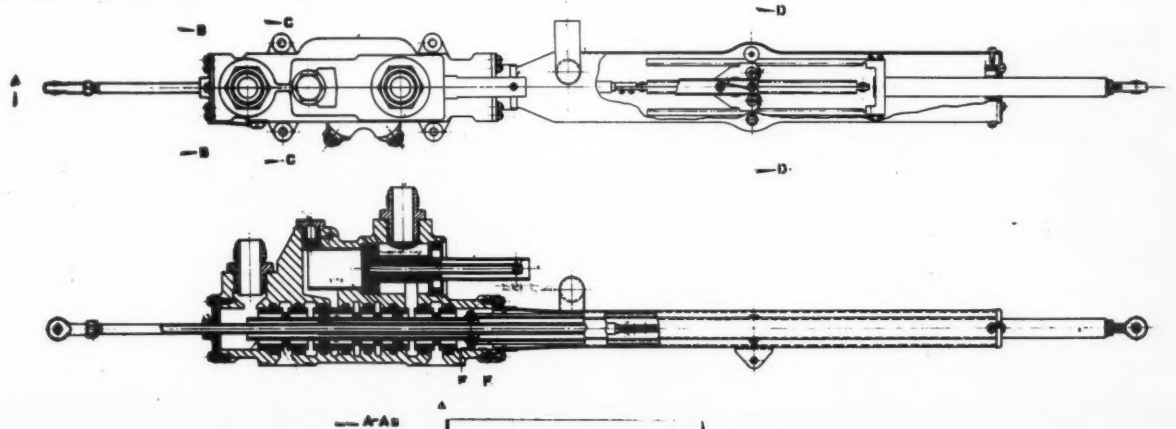
The end bells of the air cylinder are made of 24 ST aluminum alloy and are retained in the barrel by means of snap rings. The front end bell contains a self-aligning bearing and scraper ring for the piston rod. The bearing consists of a spherical section of carbon-graphite material with a close tolerance hole for the piston rod. The spherical section mates with two contoured bronze shoes, the whole assembly then being retained in the end bell by a snap ring. The aft end bell contains the passages and machined threads for attaching the hydraulic piston.

The piston rod is made of 4130 steel with a ground finish on both the outside and inside. The inside is finished, because it acts as the cylinder for the integral hydraulic system. End bells are provided for this cylinder and are retained in place with snap rings. The hydraulic piston and end bells are made of 24 ST aluminum alloy, while the piston rods are chrome-plated 4130 steel. The piston rod is designed as the inlet and outlet passages for the hydraulic system and is carried back through the air cylinder end bells to the outside of the unit. Since the maximum operating pressure of the hydraulic system is approximately 3,500 lbs. per sq.in., backup rings are used with all O-rings and were made of Teflon plastic.

The servo-valve assembly shown on Fig. 5 consists of the piston valve, the feedback mechanism, and the fluid reservoir. The valve body is an aluminum casting of 356-T6 material. It is internally ported for both the oil and air circuits. Inserted in the body is a piston and sleeve assembly. These were made of AISI 440 stainless steel hardened to approximately Rockwell C-58. The inside diameter of the sleeve is 1.25 in., and the length is approximately 8 in. The piston and sleeve were lapped together and contain no other seals between the various sections. Silicone O-rings are spaced along the outside of the sleeve to isolate the various circuits in going from the sleeve to the aluminum housing. Satisfactory operation of this valve was not achieved initially but was attained after several changes in construction which were not taken into account on the first design. The first valve had O-ring



CYLINDER ASSEMBLY-FIGURE 4



VALVE ASSEMBLY-FIGURE 5

seals between the oil and air section, but preliminary tests showed the breakaway friction of the valve exceeded the 5-lb. force set up as a design aim. The O-ring seals were removed and replaced by a lapped fit section with equalizing grooves cut into the outside diameter. Because of the air-oil balanced pressure design, which will be described later, little leakage was encountered with a great improvement in the valve actuating force.

As higher actuating loads were studied, it was noted that the valve actuating force went up and was again excessive. Instrumentation showed the hydraulic pressure increased as the load increased, and it was suspected some sort of hydraulic lock was occurring in the valve.

The first try at a cure involved increasing the diametral clearance between the piston and the sleeve. This only aggravated the condition and increased the actuating forces at a lower hydraulic pressure. The next step was to relieve the lands or surfaces of the piston to diminish the contact area between the piston and the sleeve. This was accomplished in two stages and effectively decreased the actuating force to a reasonable value. The original land width was approximately $^1/_4$ in.; the final width was a strip at each edge of the land of approximately $^1/_{32}$ in.

The original valve design had equal port areas for hydraulic fluid passage to and from the locking cylinder. Consequently, severe cavitation was encountered on the suction side of the cylinder during high actuating velocities. Because of the design of the hydraulic section of the valve, however, the hydraulic fluid from each side of the cylinder always entered and left the valve by its own individual port. The improved valve was therefore made with increased area on the leaving or suction ports, thereby alleviating the cavitation problem.

Connected to the valve piston is the spur gear of the differential. The two racks form the other two components of the differential, one of which is fastened to the piston rod to feed back the output position, while the other accepts the input signal from the input rod. In the actual design, two sets of racks and pinions are used in order to balance the gear-tooth separating forces, thereby keeping the internal friction to a minimum. Since any play in the differential would act as error signals to the valve, spring-loaded split gears are used to eliminate backlash. The entire differential assembly is enclosed in a stamped aluminum housing for protection and support.

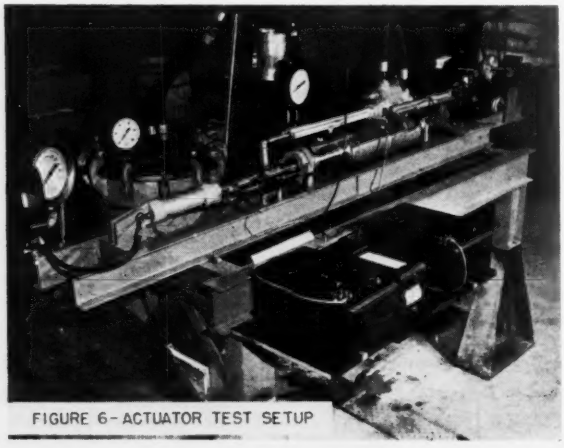


FIGURE 6-ACTUATOR TEST SETUP

Enclosed in the cast aluminum valve housing is the fluid reservoir. The piston of the reservoir is loaded by a 5-lb. spring and also by the air supply. This balances the air and oil sections of the valve so that the only pressure on the oil in the static condition is due to the spring, thereby practically eliminating leakage of oil when the actuator is pressurized, but not being used. Any loss of fluid past the various seals, however, is made up from the reservoir. The design of the actuator is such that any leakage that might occur is scavenged by exhaust air that can be dumped overboard, eliminating any fire hazard.

After completing the first prototype actuator, a test program for determining the actuator performance was initiated. In general, this was to gather information on response, time constants, and characteristics, as functions of operating flight conditions.

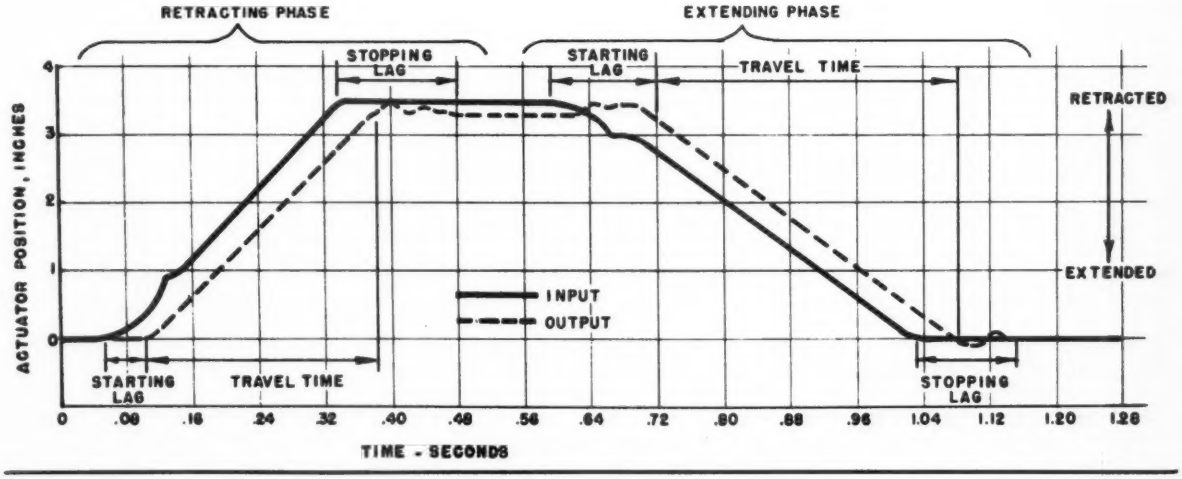
Fig. 6 is a photograph of the test setup. The actuator is loaded by means of a hydraulic cylinder, the pressure of which is maintained by a controlled nitrogen-loaded accumulator. The nitrogen is supplied from a commercial 1,500 lbs. per sq.in. bottle. Input signals are applied by a motor-driven reduction unit. The low-speed rotational movement is changed into reciprocating movement by means of a crank and connecting rod arrangement. Changes in linear input velocity and stroke are accomplished by changing the throw on the crank arm and the speed of the motor. Air is supplied to the actuator through a large surge tank to minimize pressure fluctuations. Input and output movements are recorded on a direct-reading oscillograph recorder. These movements are fed into the recorder by means of a slide wire potentiometer mounted on the input and output rods.

In studying the performance of the actuator, a useful parameter was found to be the force ratio. This ratio is the simulated opposing force divided by the available actuator air force. An analysis of the flight operating conditions showed that the operating range of the actuator would be for a force ratio from approximately 0.4 to 0.8. Fig. 7 is taken from the actual recorder data and gives a good insight into the operating characteristics of the actuator. In this case, the force ratio is 0.6, the air pressure 30 lbs. per sq.in. gage, and the stroke approximately $3^1/_2$ in. The heavy line is the input trace, and the dotted line is the output trace. These traces are shown plotted against time. The output started to move about 0.04 sec. after the input and came to complete rest about 0.14 sec. after the input had stopped. Some input instability is noted on stopping. At any time, the output is approximately $^1/_2$ in. behind the input. Smoothness of servo action may be noted by the parallelism of the input and output

PERFORMANCE CHARACTERISTICS— FIGURE 7

$$\text{FORCE RATIO} = \frac{\text{OPPOSING FORCE}}{\text{ACTUATOR AIR FORCE}} = .6$$

AIR SUPPLY PRESSURE = 30 PSIG



traces. The actuator velocity calculated from the traces is almost a constant 12.5 in. per sec.

Fig. 8 is a plot of the maximum actuator speed against force ratio, and, as is to be expected, the highest speeds for extending actuator occur at the lowest force ratio where the actuator force dominates.

For the retracting actuator condition, the reverse is true. Because of the design of the afterburner nozzle the loading on the actuator was in one direction. That is, when the actuator extended, the load opposed it; but, when the actuator retracted, the load helped it. This meant that the actuator stabilizing system would have to be overdesigned in order to withstand the shock loads of stopping both the actuator mechanism and the applied load from the afterburner nozzle. The actuator was, therefore, designed with full actuating force in extending condition and with one-third actuating force in the retracting condition. Since the power section of the actuator consisted of three air cylinders in series, this was easily accomplished by allowing two of the retracting sections to breathe atmospheric air during retraction. Actuator loading was such that, at certain operating conditions, a definite retracting force was required; one-third of the normal actuating force was adequate for this condition.

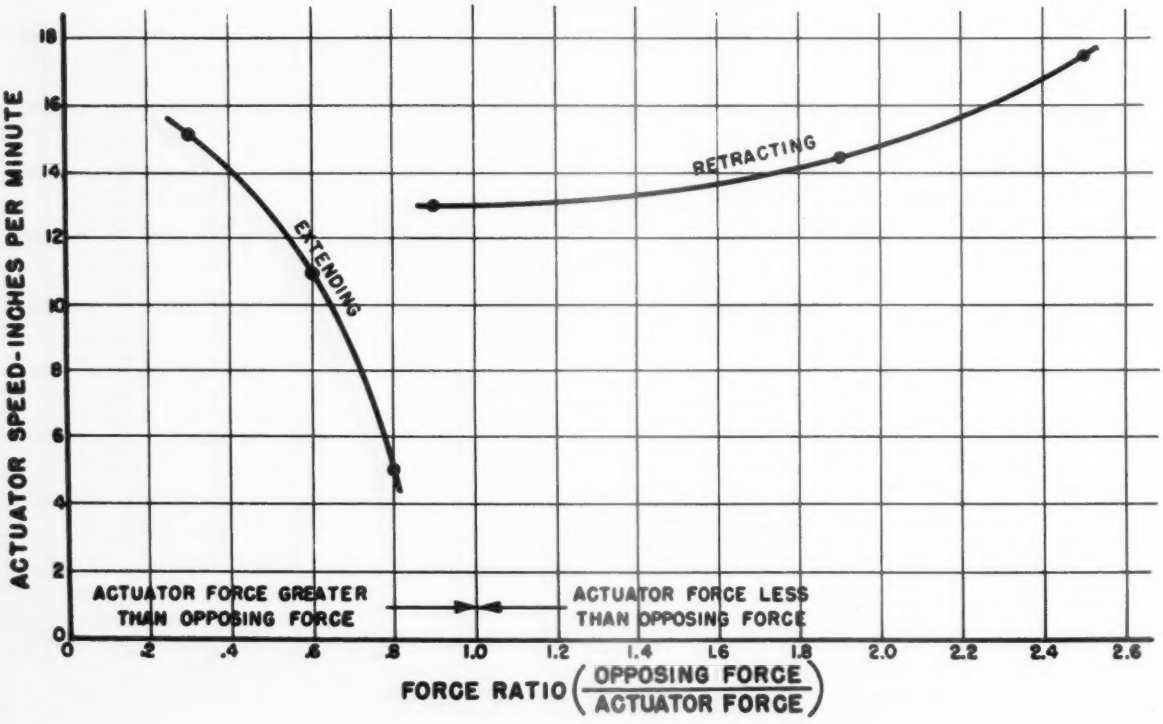
Fig. 9 shows how the starting and stopping time lags between input signal and actual output movement vary with the force ratio. In this case, the extending lags are greatest at the higher force ratio. This is as expected, since the net force available for movement is least at this condition.

In addition to the performance testing of the actuator, development work was done on seals and hydraulic fluids. Generally, this involved the immersion of seal materials in hydraulic fluids for extended periods of time at a fluid temperature of 400°F. Periodic observations were made of the seal, volume, weight, softness, and elasticity. In addition, visual checks on both the fluids and seals were made. The final materials used were a silicone fluid as the hydraulic medium and a silicone rubber as the seal material. The silicone rubbers are specially compounded to resist the leaching, swelling, and solvent action of the silicone fluid. Tests of the fluid on other parts of the actuator, including the Teflon backup rings, showed these combinations to be satisfactory.

Today in the aircraft industry there is a definite trend toward pneumatically operated devices. This is primarily due to the vulnerability of the other operational circuits and the associated dangers that go with using inflammable materials in a hot-gas plant. Most manufacturers believe that the future power-transmitting medium used in aircraft will be high-pressure air. Many functions of the airplane today are satisfactorily using pneumatics. One application, however, usually reverts to hydraulics or electricity. That application is in pure servo-boost devices. Aircraft

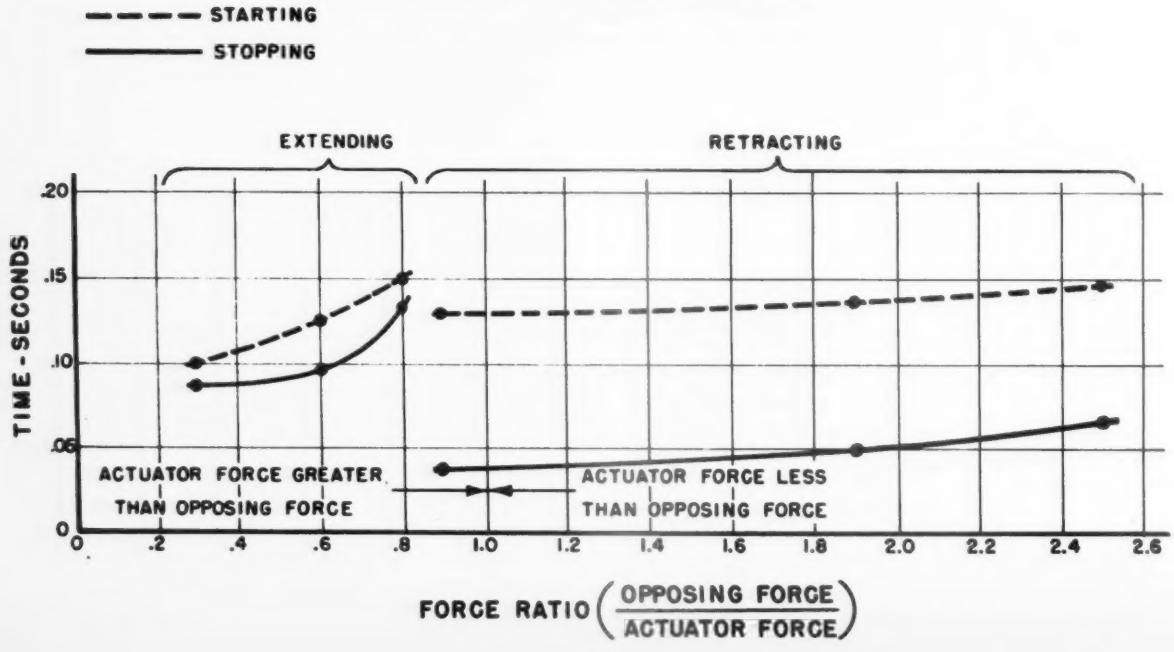
PERFORMANCE CHARACTERISTICS — FIGURE 8

ACTUATOR SPEED VS FORCE RATIO
AIR SUPPLY PRESSURE = 40 PSIG



PERFORMANCE CHARACTERISTICS — FIGURE 9

INPUT-OUTPUT TIME LAGS VS FORCE RATIO
AIR SUPPLY PRESSURE = 40 PSIG



now, and in the immediate future, are being designed for supersonic flight, which entails tremendous forces, both on the airplane structure and its controls. The only possible way satisfactorily to operate the primary controls in these airplanes is by means of servo-boost systems.

The working models of the actuator described in this paper have been designed for low-pressure operation—i.e., jet-engine compressor discharge pressure. The size of this device is, therefore, rather large. Pneumatic systems are now being installed in aircraft with operating pressures of between 1,500 to 3,000 lbs. per sq.in. This means that an actuator could be designed with a weight and size which would be directly comparable to a standard aircraft hydraulic actuator and probably much smaller than electric actuator of equivalent output.

There are probably many other uses for which this actuator principle could be adapted, but it is not within the scope of this paper to go into the requirements of the servo units. It can only be hoped that, by describing this unique device, we may inspire others to ideas furthering the fields of hydraulics and pneumatics.

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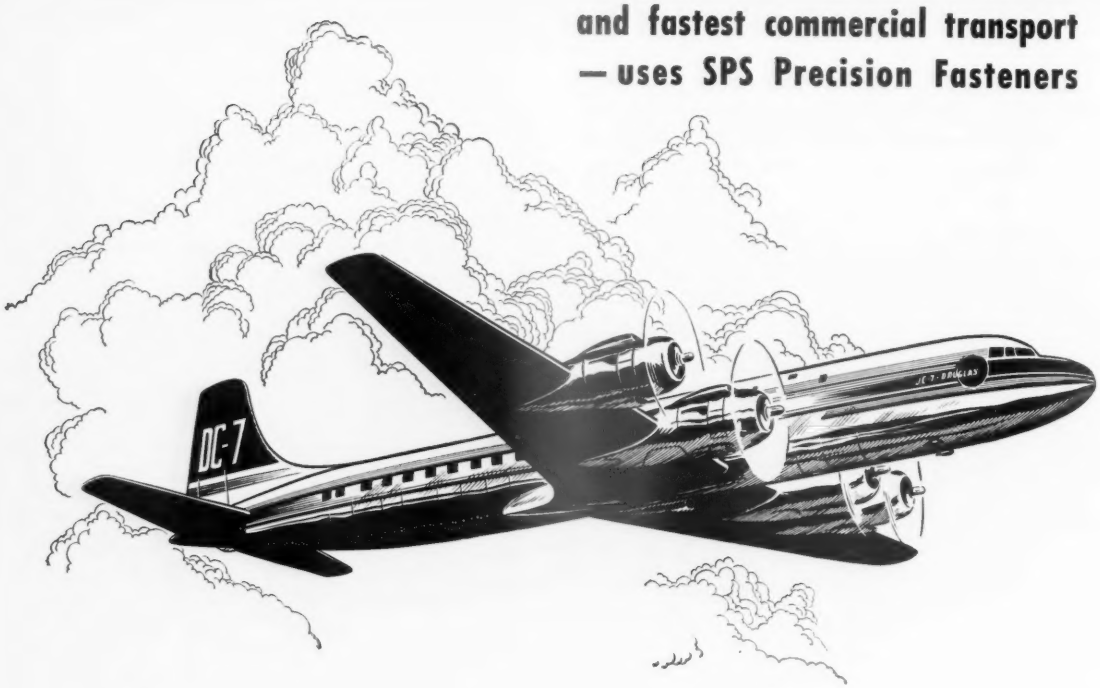

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IAS Previews

Summaries of Current Papers Accepted for IAS Publications

Problems and Results of Investigations on Cascade Flow

By

H. Schlichting

Institute of Fluid Mechanics, Technical University of Braunschweig, Germany

A summarizing report is given of the research work on the flow through cascades of airfoils, which has been conducted in recent years at the Institute of Fluid Mechanics at the Technical University of Braunschweig. The theoretical investigations led to a simple solution of the "Indirect Problem" and the "Direct Problem" for the two-dimensional incompressible frictionless flow through cascades. By an extensive computation of "Cascade Downwash Tables," the amount of calculation for any special case has been reduced to such an extent that a systematic theoretical investigation of the cascade problem has become possible.

Two-dimensional viscous flow through cascades has been treated by applying boundary-layer theory, thus giving for the first time theoretical data for the loss coefficients. An extensive theoretical program, which aims to explore the relations between the geometric and aerodynamic parameters of cascades, including loss coefficients, has been started and partly completed.

For the two-dimensional compressible flow through cascades at high subsonic velocities, a convenient method of computation has been given which is based on the Prandtl-Glauert rule. In this way, the above-mentioned solution of the "Direct Problem" for incompressible flow has become applicable also to compressible subsonic flow.

The theoretical results have been checked by some systematic experiments on two-dimensional cascades. Special attention has been given to obtain two-dimensional flow by means of boundary slots at the walls and by applying suction. Pressure distributions, as well as loss coefficients, as obtained from experiments are in good agreement with theory.

Furthermore, numerous experiments have been done with cylindrical axial-flow cascades having various hub ratios and untwisted blades. These cascades were tested with axial inflow, thus giving a considerable swirl of the outflow. By comparison with tests on two-dimensional cascades with blades of the same profile, it has become evident that for cylindrical cascades the effects of radial divergence—i.e., the variation of the solidity ratio over the radius—on the pressure distribution over the blade and on the local loss coefficients are generally extremely small. Also, some research has been done on two-dimensional cascades with clearance.

General Instability of Simply Supported Rectangular Plates

By

J. R. M. Radok

Aeronautical Research Laboratories, Melbourne, Australia

The problem of lateral bending of thin plates, stiffened by line reinforcements, is reduced to the limiting case of uniform plates under triangular loading, distributed over a strip, when the width of the strip tends to zero. Using the basic solutions arising from this limiting process, the characteristic equations for the compressive buckling loads of rectangular plates, reinforced by stringers, by ribs, by distributed stringers, and by discrete ribs are deduced. In all these cases closed expressions in terms of elementary functions are obtained for arbitrary spacing of the reinforcing members, and it is shown that the case of discrete stringers and ribs cannot be solved in a similarly simple manner.

Skin Friction in Slip Flow

By

S. A. Schaaf and F. S. Sherman

University of California at Berkeley

Skin-friction data in the slip flow régime are presented, covering the range: $0.008 < M/\sqrt{Re} < 0.38$; $34 < Re < 2{,}020$ for $2.5 < M < 3.8$; $3 < Re < 500$ for $M \sim 0.2$ and 0.6. The results are discussed in terms of the various relevant theories, and it is inferred that, in the neighborhood of $Re = 1{,}000$, the dominant effect is the interaction between boundary layer and external flow which increases the skin friction, but that, in the neighborhood of $Re = 50$, the dominant effect is that of slip that decreases the skin friction.

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Linearized Theory of the Oscillating Airfoil in Compressible Subsonic Flow

By

R. Tinman

Technological University, Delft, Holland

Extending previous work, a series expression in Mathieu functions is given for the pressure distribution on an oscillating airfoil in two-dimensional subsonic flow. Using an identity between different solutions of the corresponding boundary value problem, it is shown that the resulting formula satisfies the reciprocity relations in nonstationary flow.

The Bursting Speed of a Rotating Plastic Disc

By

H. J. Weiss and W. Prager

Brown University

The paper presents an analysis of the stresses and strains in a fully plastic, rotating, annular disc that has initially uniform thickness and is made of a strain-hardening material. This analysis is based on Tresca's yield condition and the associated flow rule and assumes that the elastic strains may be neglected in comparison with the finite plastic strains that

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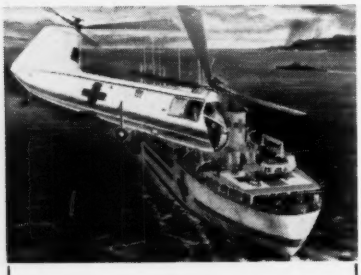

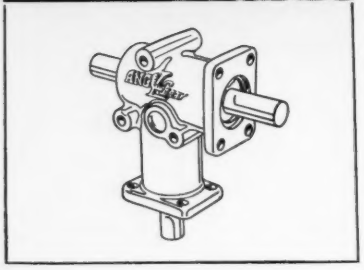

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are considered. The bursting speed of the disc is expressed in the form of a definite integral that involves the strain-hardening function of the material. In general, this integral must be evaluated numerically, but analytical evaluation is possible for certain strain-hardening functions. In particular, it is shown that, for linear strain-hardening, instability can occur only at the onset of plastic flow, whereas for logarithmic strain-hardening considerable plastic deformation of a stable character may occur before the process of deformation becomes unstable at the bursting speed.

Turbulent Boundary Layers in Adverse Pressure Gradients

By
Francis H. Clauser
The Johns Hopkins University

An experimental study has been made of turbulent boundary layers in adverse pressure gradients which were established in such a way that, for each layer, the profiles, when plotted in a set of universal coordinates, are of similar shape. A comparison is made with the corresponding set of laminar profiles. Results are presented for the effects of Reynolds Number, pressure gradient, and roughness on skin friction. It is shown that boundary layers in moderately high adverse gradients will not exhibit what is termed "downstream stability." A comparison is made of the present experimental results with conventional methods of predicting the effect of pressure gradients on turbulent boundary layers, and it is shown that the agreement is poor.

Survey of Friction Coefficients, Recovery Factors, and Heat-Transfer Coefficients for Supersonic Flow

By
Joseph Kaye
Massachusetts Institute of Technology

A brief survey is presented of the progress made in the last 4 years on theoretical and experimental work on friction coefficients, recovery factors, and heat-transfer coefficients for supersonic flow of air.

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IAS News

(*Continued from page 23*)

peratures, by Professor Brull; nonstationary aerodynamics, by Dr. L. Arnold, Arnold Associates; problems of aeroelasticity, by Dr. Arnold; what price speed, by Dr. K. S. M. Davidson, Stevens Institute of Technology; recent developments in the theory of turbulence, by Prof. G. Kovásznay, The Johns Hopkins University; new experimental results on turbulence in the supersonic range, by Professor Kovásznay; structural problems at high speeds, by Dr. R. V. Rhode, NACA; wing characteristics at high speed, by K. Van Every, Douglas Aircraft Company, Inc.; and wing stability at high speed, by Mr. Van Every.

The Seminar's closing meeting on September 24 featured a lecture by Dr. von Kármán on "Combustion Problems."

A great number of Italian aeronautical scientists and many foreign experts took part in the Seminar.

A discussion of the upper atmosphere was held at a meeting held in Boston on November 2–4 at which representatives of Government scientific and engineering agencies were present. Seen in the above picture at the opening session are, *from left to right:* Dr. Harry Wexler, Chief, Scientific Services Division, U.S. Weather Bureau; Dr. Helmut Landsberg, Director, Geophysics Research Directorate, Air Force Cambridge Research Center; Capt. W. S. Diehl, USN (Ret.), HFIAS; Dr. W. G. Brombacher, FIAS, Chief, Mechanical Instruments Division, National Bureau of Standards; and Norman Sissenwine, Geophysics Research Directorate, AF Cambridge Research Center. The purpose of this meeting, cosponsored by the AF Cambridge Research Center and the U.S. Weather Bureau, was to discuss the possibility of extending the present Standard Atmosphere from the 65,000-ft. level set in 1925. Today's aircraft are pushing this limit, and the need exists to pool information on altitudes up to more than 100,000 ft. to allow safer flying for aircraft of the future.

ASTIA Testing New Indexing System

The Uniterm System of Coordinate Indexing, a new method of indexing and retrieving information, is now being subjected to a field-test program, according to a recent announcement by Leslie E. Neville, MIAS, Director, Armed Services Technical Information Agency, Department of Defense. Developed by Documentation Incorporated under ASTIA's contractual sponsorship, this new system indicates not only saving of up to 90 per cent in present catalog space and up to 75 per cent in present cataloging time but also far more effectiveness in retrieving pertinent information.

The Uniterm System, a step in the direction of information storage and retrieval by machine methods, treats all words in the language as equal units. This automatically eliminates the vast number of word combinations contained in a language and thus restricts the size of the catalog.

In operation, the information contained in a collection of documents is analyzed into the simplest practical word units of information, thus giving rise to "Uniterm." Each of these basic words is assigned a separate catalog card, and each document to be cataloged is given a serial number. These serial numbers are posted on all cards headed by the Uniterms by which the documents have been analyzed. For example, suppose a searcher is looking for information on "air-cooled aircraft guns." Under this system, there is no need for him to search the indexing system for the six possible ways by which this information could be filed. Instead, he has only to select three Uniterm cards each bearing one of the three subject words, and to compare the cards for any and all serial numbers that they might have in common. Once the searcher has noted these serial numbers, he knows precisely where all available information on "air-cooled aircraft guns" may be obtained.

The Uniterm method makes it possible to retrieve information either by machine or manual methods. A machine is currently under development which will permit random filing and retrieval of Uniterm cards for posting and searching. A completely automatic indexing machine is also in the process of being developed to present document numbers in answer to reference questions typed out on the conventional typewriter keyboard.

Air Flight Structures Study Center Established at Columbia University

The Daniel and Florence Guggenheim Institute of Air Flight Structures has been established at Columbia University's Engineering Center and began operation on January 1 of this year. This new educational and research unit was provided for by a grant of $329,000 from the Daniel and Florence Guggenheim Foundation, of which Harry F. Guggenheim, IAS Honorary Member, Member, Benefactor, and Founder Member, is President.

In the Guggenheim Foundation-Columbia University announcement of this new Institute, Mr. Guggenheim explained that it has a fourfold purpose. The objectives are: (1) to train exceptionally qualified graduate students in the comparatively new field of air flight structures; (2) to conduct research in aircraft structure and design, especially for supersonic flight; (3) to act as a national clearing house for technical information in this field; and (4) to disseminate technical knowledge regarding air flight structures.

The activities of the Institute are being carried out by Columbia's Department of Civil Engineering, as well as by other appropriate segments of the university, working closely with Civil Engineering. An Advisory Board is being set up to assist in guiding the Institute's activities.

Douglas Engineers Honored

C. R. Strang, AFIAS, Chief Project Engineer, and Harold Luskin, AFIAS, Assistant Chief of the Aerodynamics Section, Santa Monica Division, Douglas Aircraft Company, Inc., were among those recently honored by the University of Michigan for their "outstanding achievements and contributions to the field of engineering."

Mr. Strang, a 1928 graduate of the University of Michigan, was cited for being "responsible for the structural integrity of all recent Douglas aircraft."

In citing Mr. Luskin, the university stated that it was recognizing his "professional leadership in the field of engineering." Mr. Luskin is a 1942 graduate.

Translations Pool Established

The Special Libraries Association, in cooperation with the John Crerar

Library, Chicago, has announced a new translations service. It was established to meet the increasing need for information regarding existing translations and for the availability of inexpensive copies.

Thirteen hundred translations, forming the nucleus of the Pool, have been deposited by the Association in the Crerar Library. As the usefulness of the Pool is directly proportionate to the number of translations available, contributions are solicited from Government agencies, technical societies, universities, industries, and individuals. Contributions may be made by the deposit of good copies of complete translations. However, if no copies are available for deposit, they may be loaned to the Crerar Library for a short time with permission to microfilm, or, if it is desired by the contributor, a 35-mm. microfilm may be deposited. Permission to lend or to reproduce in photocopy is a condition of deposit.

Contributions and requests for information regarding the availability of translations should be addressed as follows: S.L.A. Translations Pool, John Crerar Library, 86 East Randolph St., Chicago 1, Ill.

In view of the recent announcement by the National Science Foundation of the establishment of a center for holding and photoduplicating scientific translations with particular emphasis on those in Russian, the S.L.A. Translations Pool is devoting itself to translations from languages other than Russian. Russian translations presently in the pool are to be transferred to the new center.

AHS Milestone

The American Helicopter Society announced that during the week of November 9 a milestone in the Society's history was reached, when Capt. Howard B. Richardson, USA, became the one-thousandth AHS member. He was welcomed into the national rotary-wing organization by AHS President Charles W. Lefever.

Captain Richardson, a rotary-wing expert in the Army's Transportation Corps, is now spending a year on duty at Piasecki Helicopter Corporation as part of the Army industrial training program. About 10 years ago, he completed paratroop training and some time later was a member of the first group of Infantry officers to be authorized to train as Army aviators. He began his training as a helicopter pilot at Bell Aircraft School in March, 1947.

Necrology

John R. Stiles

John Raymond Stiles, MIAS, died on October 22 at the Naval Hospital in San Diego, Calif. Military services were conducted at the Fort Rosecrans National Cemetery in San Diego on October 27.

Mr. Stiles was born in Paterson, N.J., on May 7, 1890. He attended high school in Springfield, Mass., for 4 years and Wesleyan University for 1 year.

In 1925 and 1926, he was an aerial photographer for Aerial Photographic Service in Chicago, Ill. During the next 12 years, he worked with Chicago Aeronautical Service, States Aircraft Corporation, Oklahoma Press, a U.S. Government Aviation Project in Chicago, and Payne Aircraft Corporation. Between 1939 and 1941, he served as District Manager of Federal Schools, Inc. Since that time, he was a Tool Process Engineer with Goodyear Aircraft Corporation and an Area Engineer, Aircraft Division of Willys-Overland Motors, Inc. At the time of his death, he was with Rohr Aircraft Corporation as Liaison Engineer.

Mr. Stiles, who held a commission in the Cavalry Reserve as a Major, is survived by his widow, Mrs. Wilma Stiles.

News of Members

▸ **Dr. Leslie A. Bryan** (M), Director, Institute of Aviation, University of Illinois, was awarded the Frank G. Brewer Trophy by President Eisenhower at the Aero Club of Washington's Wright Memorial Day Dinner on December 17. Dr. Bryan was named the 1953 winner of the Brewer Trophy for his many contributions to the development of aviation education in the United States.

▸ **F. A. Cleveland** (M), Group Engineer, Preliminary Design Division, Lockheed Aircraft Corporation, has been named to head the Preliminary Design Division's part in a preliminary design study on nuclear-powered aircraft for the Air Force.

▸ **Bernard J. Driscoll** (M), Associate Director, Advisory Group for Aeronautical Research and Development, NATO, France, was awarded the USAF "Decoration for Exceptional Civil Service." The award, presented to him on September 7 during AGARD'S Fourth General Assembly, recognized his work as Executive Secretary of the USAF Scientific Advisory Board from 1949 to 1952.

▸ **Frederick C. Durant, III** (AF), Consulting Engineer and President, American Rocket Society, was recently elected President of the International Astronautical Federation for 1953–1954. The federation is composed of rocket and space-travel societies of 13 nations.

▸ **Guillermo Gonzalez Gomez** (AM), Aeronautical Engineer, Engineering Office, San Carlos University, Guatemala, delivered the address that closed San Carlos University's celebration of the fiftieth anniversary of flight. This lecture, which was presented on December 17 at the Instituto Guatemalteco-Americano, a U.S. State Department Cultural Center, was on the subject, "The Wright Brothers and Their Contributions to the Aeronautical Sciences."

▸ **The Honorable Carl Hinshaw** (M), Member of Congress, U.S. House of Representatives, Washington, D.C., was awarded the 1953 Wright Brothers Memorial Trophy at the Aero Club of Washington's Wright Memorial Day Dinner on December 17. The presentation was made by President Eisenhower. This trophy is presented annually to an American citizen for "significant public service of enduring value to aviation," such service being in a civilian capacity. It is awarded for service over a period of years rather than for achievement in a specific year. In selecting Mr. Hinshaw as the 1953 recipient, the award committee felt that his many comments and speeches on the floor of the House have contributed greatly to a better understanding by the Government and the public of aviation's problems.

▸ **J. H. Kindelberger** (HF), Chairman, Board of Directors, North American Aviation, Inc., has been elected to the Board of Directors of the National Aeronautic Association.

▸ **Charles A. Lindbergh** (F) was honored at a banquet given in St. Louis on October 30 by the National Business Aircraft Association. The award was presented to him *in absentia* as the man who has contributed most to the progress of aviation.

▸ **Paul J. Papanek** (M), Eastern District Manager, Marquardt Aircraft Company, has been elected Assistant Secretary of the company. Mr. Papanek remains at Dayton, Ohio, where he is in charge of Marquardt's local office.

▸ **William A. Patterson** (M), President, United Air Lines, Inc., was recently elected to the Board of Direc-

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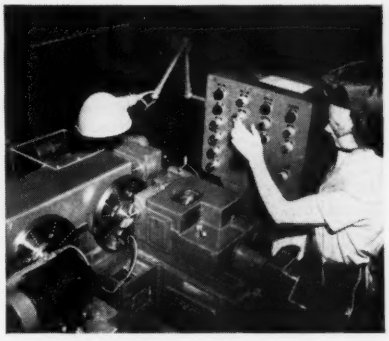

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Cloyce J. Tippett, MIAS, South American Regional Director, International Civil Aviation Organization, was recently awarded the Peruvian Flying Cross, First Class, for "distinguished services in the field of international civil aviation." Mr. Tippett is the second civilian to receive this decoration, the highest award in Peruvian aviation.

tors of Westinghouse Electric Corporation.

▸ **C. G. Peterson** (M) retired on November 1 as Chief Engineer, Railway Express Agency, Inc., a position that he had held since 1938. Before joining Railway Express in 1934, Mr. Peterson was associated with Wright Aeronautical Corporation as Assistant to the President, Ford Motor Company's Airplane Division as Sales Manager, and Martz Airline Company as Vice-President and General Manager.

▸ **Theodore P. Wright** (HF), Vice-President for Research, Cornell University, has been appointed Chairman of the Board of Trustees of Associated Universities, Inc. Associated Universities is comprised of a group of nine eastern universities that administer the Brookhaven National Laboratory under contract with the Atomic Energy Commission.

Members on the Move

The purpose of this section is to provide information concerning the latest affiliations of IAS members. All members are therefore urged to notify the News Editor of changes as soon as they occur.

Burnham Adams (AF), Manager—Sales, Field Service and Contract Administration, Manufacturing Division, Pacific Airmotive Corporation. Formerly, Sales Manager, AiResearch Manufacturing Company, Division of The Garrett Corporation.

Lieutenant Colonel Francis B. Carlson (M), Assistant Development Test Officer, 4925th Test Group (ATOMIC), Air Force Special Weapons Center, Kirtland AFB, N.M. Formerly, Assistant Director, Research and Development Division, Armed Forces Staff College, Norfolk, Va.

David Cochran (M), General Manager, Aircraft Gas Turbine Development Department, Aircraft Gas Turbine Division, Evendale (Ohio) Plant, General Electric Company. Formerly, Manager—Laboratories, Development Operation, Aircraft Gas Turbine Division, G-E.

Frank R. Cook (AF), Head, Research and Planning, Aeronautical Division, Minneapolis-Honeywell Regulator Company. Formerly, Director, Aeronautical Engineering, Aeronautical Division, Minneapolis-Honeywell.

Dr. George Gerard, AFIAS, has been appointed Assistant Director, Research Division, College of Engineering, New York University. Dr. Gerard, who was formerly Assistant to the Director of the College of Engineering's Research Division, was awarded his Doctor of Engineering Science degree by N.Y.U. in 1950. He has been associated with the College of Engineering since 1947.

Dean C. Smith, MIAS, who recently joined Lear, Incorporated, as Director of Customer Relations, has been elected a Vice-President of the company. Mr. Smith came to Lear from Hughes Aircraft Corporation where he was Director of Customer Relations since 1948. Prior to that time, he was Director of Development, Fairchild Engine and Airplane Corporation, and Director of Transport Aircraft, Curtiss-Wright Corporation.

Homer J. Wood, MIAS, has established his own business and is now Consulting Mechanical Engineer in the fields of turbomachinery and high-speed mechanisms. Mr. Wood resigned on October 15 from his position as Assistant Chief Engineer, AiResearch Manufacturing Company. He had been with AiResearch for over 10 years.

Second Lieutenant Robert G. Dubinsky, USAF (TM), Project Officer, Headquarters, Air Force Special Weapons Command, Kirtland AFB, N.M. Formerly, Stress Analyst, Thieblot Aircraft Corporation.

James B. Edwards (AF), Project Engineer, Santa Monica Plant, Douglas Aircraft Company, Inc. Formerly, Chief Engineer, Hiller Helicopters.

Rune L. Evaldson (M), now with Department of Mechanical and Industrial Engineering, University of Michigan.

George B. Gaston (AM), Sales Engineer, Creative Industries of Detroit. Formerly, Field Engineer, Pittsburgh Pipe Cleaner Company.

Edward S. Geller (TM), Assistant Project Engineer, Sperry Gyroscope Company, Division of The Sperry Corporation. Formerly, Aeronautical Research Scientist, Langley Aeronautical Laboratory, NACA.

N. E. Halaby (M), Adviser to Laurence Rockefeller, New York. Formerly, Deputy to Assistant Secretary of Defense (International Security Affairs), Office of the Secretary of Defense, Washington, D.C.

Meir Hanin (TM), with Department of Aeronautical Engineering, Technion—Israel Institute of Technology, Haifa, Israel. Formerly, Graduate School of Aeronautical Engineering, Cornell University.

Second Lieutenant Robert H. Hansen, USAF (TM), now Aeronautical Engineer, Modifications, Plans and Design Section, Hq., 6520th Maintenance and Supply Group, Laurence G. Hanscom Field, Mass.

Lieutenant Martin H. Harris, USAF (TM), Development Directorate, Headquarters, Air Force Special Weapons Center, Kirtland AFB, N.M. Formerly, Test Engineer, Wright Aeronautical Division, Curtiss-Wright Corporation.

Dr. Harvard L. Hull (AF), Vice-President and General Manager, Research and

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In industries other than aircraft where hardened and precision ground parts are required in substantial volumes, Allied is also a primary supplier. To meet *your* present or future needs for such parts, Allied has the well-organized facilities and proven ability to produce them quickly, economically and in strict adherence to your specifications. We'll be glad to receive your part prints for quotation.

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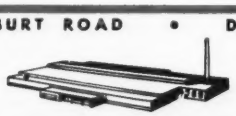

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The introduction of the 3SP type Waterman RAYONIC cathode ray tube was greeted with great enthusiasm. Its unique applications have since more than justified that enthusiasm. From a mechanical standpoint alone, this acceptance has been based upon the fact that two 3SP cathode ray tubes occupy the same space as a single 3 inch round tube—a feature which makes the tube an outstanding performer in multi-trace work. Up to ten tubes have been mounted across a standard relay rack panel without crowding. The low deflection factors of the 3SP have still further widened its use in single cathode ray tube video devices. The choice of screen is optional and available in P1, P2, P7 and P11 phosphors. We are authorized to supply the 3SP1 with JAN stamping. Let the 3SP type Waterman RAYONIC cathode ray tubes add their new concept of compactness to your own equipment.

3SP TECHNICAL DATA

SIZE:		
FACE	1½ x 3 inches	
LENGTH	9.12 inches	
BASE	Small Duodecal 12 Pin	
TYPICAL OPERATING CONDITIONS		
FILAMENT	6.3 Volts	
	0.6 Amps.	
ANODE #2	Max. 2750 Volts	
	1000 Volts	2000 Volts
ANODE #1	165 to 310	330 to 620 Volts
GRID #1	−28.5 to −67.5	−58 to −135 Volts
DEFLECTION FACTOR IN VOLTS/INCH		
D1 to D2	73 to 99	146 to 198
D3 to D4	52 to 70	104 to 140

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Development Division, Capehart-Farnsworth Company, Division of International Telephone and Telegraph Corporation. Formerly, Director, Remote Control Engineering Division, Argonne National Laboratory.

Miss Rosalyn E. Hyde (M), Test and Development Engineer, Missile Division, Chrysler Corporation. Formerly, Stress Analyst, New York City Engineering Office, Republic Aviation Corporation.

Edward C. Klein (TM), now Design Engineer, Aeronca Manufacturing Corp.

Ellis Lapin (AF), Assistant Supervisor—Aerodynamics for Research, Santa Monica Division, Douglas Aircraft Company, Inc. Formerly, Aerodynamicist, Santa Monica Division, Douglas.

Harold Luskin (AF), Assistant Chief, Aerodynamics Section, Engineering Department, Santa Monica Division, Douglas Aircraft Company, Inc. Formerly, Assistant Supervisor—Aerodynamics for Research, Santa Monica Div., Douglas.

J. S. Parker (M), General Manager, Small Aircraft Engine Department, and Acting General Manager, Aircraft Accessory Turbine Department, Aircraft Gas Turbine Division, River Works Plant, General Electric Company, West Lynn, Mass. Formerly, Manager, Facilities and Idaho Operations, Aircraft Nuclear Propulsion Project, G-E.

Commander Louis G. Pooler (M), Test Department, U.S. Naval Ordnance Test Station, Inyokern, China Lake, Calif. Formerly, Aeroballistics Department, Naval Ordnance Laboratory, White Oak, Silver Spring, Md.

S. Radhakrishnan (TM), Graduate Student and Research Assistant, Department of Aeronautical Engineering, New York University. Formerly, Student, College of Aeronautics, Cranfield, England.

James C. Ray (M), Associate Engineer, Applied Physics Laboratory, The Johns Hopkins University. Formerly, Layout Draftsman, Piasecki Helicopter Corporation.

Charles M. Schoenberg (TM), Associate Engineer, Missiles Division, Aerodynamics Group, Santa Monica Plant, Douglas Aircraft Company, Inc. Formerly, Dynamics Engineer, Consolidated Vultee Aircraft Corporation.

John F. Scott (M), Engineering Designer "A," Ryan Aeronautical Company. Formerly, Supervisor de Engenharia, Confort Air S/A, Brazil.

Robert Solverson (TM), now Research Engineer, Santa Monica Plant, Douglas Aircraft Company, Inc.

John Ross Stainton (AM), General Sales Manager, British Overseas Airways Corporation. Formerly, Manager, North America, B.O.A.C.

Edward N. Townsend, Jr. (M), Works Manager, Lockheed Aircraft Service-International, New York International Airport, L.I., N.Y. Formerly, Superintendent, Supply and Controls, L.A.S.I., N.Y. International Airport.

John Wolansky (TM), Design Engineer, Willoughby Plant, Thompson Products, Inc. Formerly, Aeronautical Engineer, Wright-Patterson AFB, Ohio.

Corporate Member News

• **Aerojet-General Corporation, Subsidiary of The General Tire & Rubber Company.** . .William E. Zisch was recently elected Vice-President of Aerojet. Mr. Zisch, who is a member of the corporation's Board of Directors, was formerly General Manager.

• **AiResearch Manufacturing Company, Division of The Garrett Corporation.** . .A $56,000 fund has been established at California Institute of Technology for the support of teaching and research in the history of science. As a result, a general course in the history of science and a research project in the history of flight under pressurized conditions are being instituted at CalTech.

• **Allis-Chalmers Manufacturing Company.** . .A 72-year-old Harvey, Ill., firm, The Buda Company, was taken over by Allis-Chalmers on November 1. It is being operated as "The Buda Company, a Division of Allis-Chalmers" and is continuing its manufacture, distribution, and servicing of all items in its regular line of products.

• **Aviation Engineering Division, Avien-Knickerbocker, Inc.** . . .By redesigning, miniaturizing, and repackaging the three-unit capacitance-type aircraft fuel-gaging system into a two-unit system, AVIEN was able to reduce the number of parts by 158 and connections by eight. The two-unit system has 70 parts and six connections; the three-unit system has 228 parts and 14 connections. Tests of the two-unit system, introduced last June, have reportedly shown that considerable savings in installation and maintenance costs can be expected of the two-unit system.

• **Beech Aircraft Corporation.** . .Campos Rueda and Sons, Inc., of Manila, P.I., was appointed a distributor for Beech in the Philippine Island area.

• **Bendix Aviation Corporation, Eclipse-Pioneer Division.** . . The Alaskan Aircraft Equipment Supply Company, of Anchorage, has been appointed a distributor for Eclipse-Pioneer's commercial aircraft products.

• **Bendix Aviation Corporation, Pacific Division.** . .A new engineering building is now under construction to accommodate the expansion of the Pacific Division's Airborne and Hydraulic Engineering departments. This is the fourth building to be built since 1948 to take care of the division's growth.

• **Boeing Airplane Company and The Cessna Aircraft Company.** . .On July 16, Cessna's XL-19B powered by a Boeing XT50-1 turboprop engine was flown to an altitude of 37,063 ft. over Wichita, Kan. This flight has been officially approved by by Fédération Aéronautique Internationale as a new world's light-plane altitude record in its weight category. The former record was 30,203 ft. set in January of 1951 over Miami, Fla., in a Piper Super Cub.

• **Chance Vought Aircraft Division, United Aircraft Corporation.** . .The construction of a low-speed wind tunnel for use in Chance Vought's jet aircraft and guided-missile program was scheduled to begin late last year and to take nearly a year to complete. This tunnel, which will cost approximately $1,000,000, will produce speeds ranging up to 200 m.p.h. When completed, it will be used in place of those facilities that the company has been using throughout the United States. The wind-tunnel building will have an overall size of 60 by 150 ft. and will house a 1,500-hp. electric motor turning a 20-ft. propeller. Test models will be mounted on three points in a chamber measuring 7 ft. high by 10 ft. wide. Attitude of the model and tunnel speed will be remotely controlled from a console in the control room. Actual high-speed wind-tunnel work will continue at various high-speed tunnels such as the ones at United Aircraft Corporation in East Hartford, Conn., and Cornell Aeronautical Laboratory, Inc.

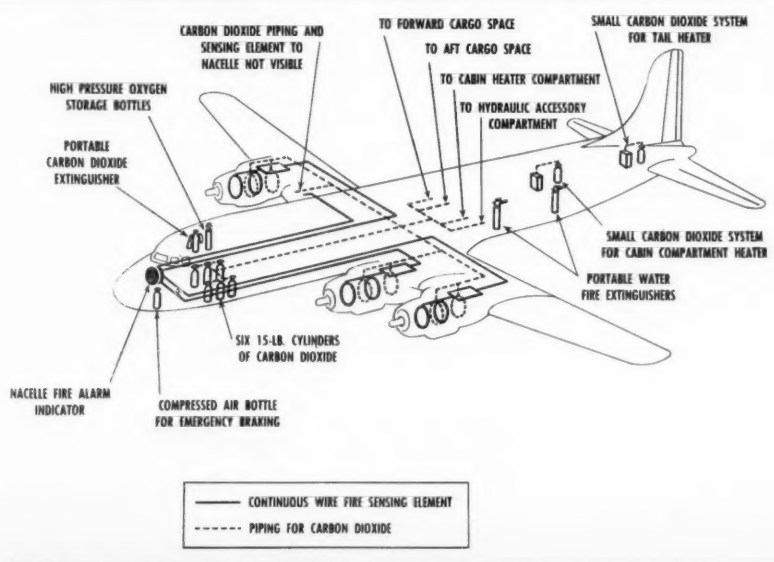
• **Consolidated Vultee Aircraft Corporation.** . .The Convair F-102, a delta-wing supersonic all-weather fighter, made its first flight on October 24 at Edwards AFB, Calif. The single-place F-102 is powered by the Pratt & Whitney J-57 turbojet engine. . . .Robert F. Windfohr, who recently served as President of Texas Mid-Continental Oil and Gas Association, has been elected to Convair's Board of Directors.

• **Douglas Aircraft Company, Inc.** . . .Another British-held speed record, this one for the 100-km. closed circuit, was returned to the United States on October 16. On that date, Douglas Test Pilot Robert O. Rahn flew a Douglas-Navy F4D Skyray around the closed course at 728.110 m.p.h. This topped the 709.2 m.p.h. set on September 19 by a British Hawker Hunter jet fighter. The plane used to set this new 100-km. closed-circuit speed record was the same one that brought another British-held record, for the 3-km. straightaway dash, back to this country on last October 3. For details of the October 3 record flight, consult the Douglas item in last month's Corporate Member News.

• **Fletcher Aviation Corporation.** . .Basic patents covering "jet cooling" and muffling systems have been purchased from Otto C. Koppen, FIAS, Professor, Aeronautics, Massachusetts Institute of Technology. In addition to the basic concept of augmenter cooling, the Koppen patent also covers a muffling system in which a perforated liner is inserted within an augmenter tube, and fiber glass is packed between them. New mufflers based on the Koppen patent are now in production at Fletcher as an accessory item for the "jet cooling" kit for Continental-powered Navions. The new "jet whisper" muffler accessory is available with all new Fletcher "jet cooling" kits.

• **Flight Refueling, Inc.** . . .It was announced recently that the corporation is moving to Baltimore, Md., where it will be located adjacent to Friendship International Airport. Initial facilities to be built at Friendship International Airport will include approximately 70,000 sq.ft. of office and manufacturing space. The nucleus of Flight Refueling's engineering staff was expected to move from Danbury and to be established in Baltimore sometime last month.

Nacelle Fire Sensing Elements, manufactured by Walter Kidde & Company, Inc., had their first commercial installation on the DC-7's purchased from Douglas Aircraft Company, Inc., by American Airlines, Inc. This system, which gives an immediate warning of fire in zones one, two, or three of any nacelle, is made up of a wirelike element that is connected through a test relay to a monitoring control unit. This unit provides the power for the system and the electronic circuit for actuating audible and/or visible alarms, which are located on the pilot's instrument panel. The test relay in the circuit provides for preflight and in-flight testing. A Kidde carbon-dioxide fire-extinguishing system for zones two and three of each nacelle complements the detection system.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The increasing weight and high landing speeds of modern fighters and fighter-bombers make power braking a problem. But the use of a full power brake system requires the incorporation of an auxiliary emergency system. The additional brake valves, accumulator, reservoir, means of pressurization and means to indicate that such system is functioning, all add up to a considerable weight penalty.

The Whittaker power boosted master cylinder combines two independent systems in one unit, giving the pilot power brakes and emergency brakes at a weight increase only slightly over that of a master cylinder alone. In the event of hydraulic loss or failure, a pilot's instant reaction is to increase the pedal pressure ... and this act alone puts the emergency unit in operation. He stops!

Model illustrated above is 2/3 actual size. Weight is 1.85 lbs. It represents a typical application and can be modified to secure required pressure and volume ratios. Ask us to demonstrate its operation and advantages. Write today for Design Bulletin No. 11.1.

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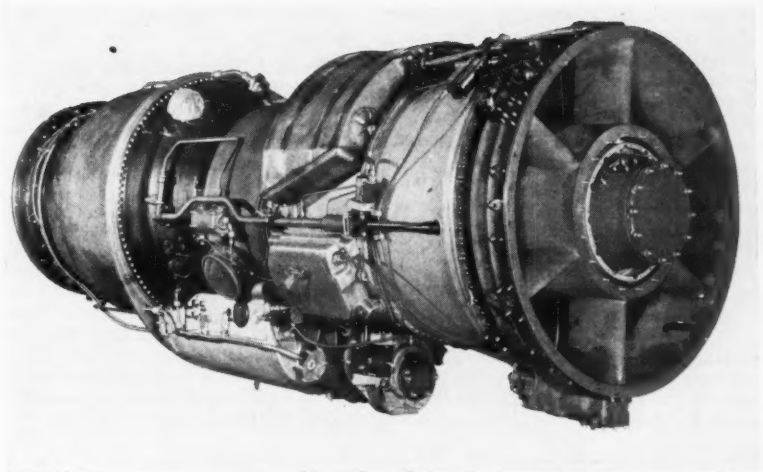
• **General Electric Company.** . .A new flight control system, designated the FC5, has been developed as a result of the joint cooperation of G-E, USAF, aircraft industry, and the USN Bureau of Aeronautics. Designed to meet the high-performance supersonic characteristics of aircraft scheduled for production beginning in 1955, the new system is said to be 35 per cent lighter and 25 per cent smaller than previous flight control systems. According to the company, the FC5 is a fundamental system concept designed to function as a single-axis stabilization system, as well as a fully automatic relief and maneuvering system. As a single-axis stabilization system, it is made up of three basic units: a rate gyro, an amplifier, and an actuator. As a fully automatic relief and maneuvering system, it is designed to perform stabilization in all three axes of pitch, roll, and yaw, in addition to functioning as a relief autopilot and as an integral part of an aircraft weapons system....Five operating departments were recently established within the company's Aircraft Gas Turbine Division. The five new departments and their general managers are: Jet Engine Department, George E. Fouch; Aircraft Gas Turbine Development Department, David Cochran, MIAS; Evendale Operating Department, Bertram W. Mahoney; Small Aircraft Engine Department, Jack S. Parker, MIAS; and Aircraft Accessory Turbine Department, with W. C. O'Connell as General Manager. The Jet Engine, Aircraft Gas Turbine Development, and Evendale Operating departments are headquartered at the G-E Evendale plant near Cincinnati. The Small Aircraft Engine and Aircraft Accessory Turbine departments have their headquarters at the company's River Works Plant at West Lynn, Mass.

• **Hamilton Standard Division, United Aircraft Corporation.** . .Two additions that will increase the factory area by some 60,000 sq.ft. are now under construction. They are scheduled for completion next summer.

• **Lear, Incorporated.** . .According to a company release, linear movement of loads up to 125 lbs. by a unit utilizing load sensitivity is now possible through a small lightweight actuator being produced by Lear. This unit, identified as the Model 396 Series Linear Actuator, weighs 1.75 lbs. and requires as little as 2.375 by 3.75 by 5.25 in. of space. Speed of operation, varying with the gear ratio and the motor utilized, ranges from 1.4 in. per sec. at 7-lb. loads to 0.045 in. per sec. at 85-lb. loads, with the smallest motor available; and from 2.35 to 0.12 in. per sec. at the maximum 125-lb. load, with the most powerful motor available. It is said to be capable of driving an opposing load of 125 lbs. through as much as 19.5 in. of travel....A Lear Aircraft Service Division was recently formed with Arthur W. Cruse as General Manager of the division. Headquartered at Santa Monica, Calif., Mr. Cruse will direct all the activities of the Lear Grand Rapids Hangar Division, Santa Monica Hangar Division, and L-5 Autopilot Division.



The U.S. Air Force disclosed on November 12 that the J-57 turbojet engine, now being produced in quantity by Pratt & Whitney Aircraft Division of United Aircraft Corporation, is officially rated in the 10,000-lb. thrust class. In commenting upon this announcement, a company spokesman said that "the engine is the first in aviation history to achieve a five-figure power rating." This axial-flow engine, shown here from the front and right side, was so designed by Pratt & Whitney to incorporate an arrangement of dual compressors in line to give the engine "a high compression ratio and an unusual fuel economy." Among the aircraft powered by the J-57 are the Boeing B-52 Stratofortress, the North American F-100 Super Sabre, and the Convair F-102. This engine is also slated to power the McDonnell F-101 and Navy aircraft.

• **Marquardt Aircraft Company.** . .Paul J. Papanek, MIAS, has been elected to the post of Assistant Secretary of Marquardt. This assignment is in addition to Mr. Papanek's duties as Eastern District Manager of the company.

• **McDonnell Aircraft Corporation.** . .The last twin-jet Banshee fighter, one of the F2H-4 "all-weather" series, was delivered to the Navy in a brief ceremony at McDonnell on October 30. The orders now on hand at McDonnell are largely for the Navy's F3H-1 Demon, a single-jet carrier-based fighter, and the USAF's F-101 Voodoo, a twin-jet swept-wing fighter.

• **Minneapolis-Honeywell Regulator Company.** . .A thimble-size transistor, which has been developed in the company's research laboratories, has an output of 20 watts. This, it is said, is 100 times as powerful as present commercially available types and enables Minneapolis-Honeywell's newly developed transistor "to do things heretofore impossible with transistors, such as the operation of motors, valves, relays and other equipment."...The company's Aeronautical Division has established a wintertime jet aircraft flight center at the Tucson (Ariz.) Municipal Airport to ensure uninterrupted work during the winter months. Flying activities are being continued at the company's main operations center in Minneapolis during the winter months for aircraft other than jets. This move is the Aeronautical Division's second decentralization, the other one being the guided-missile center at Dallas, Tex.

• **North American Aviation, Inc.** . . .The first production model of the F-100 Super Sabre rolled off the Los Angeles plant's assembly line on October 20. The wings of the F-100 are sweptback 45° and have a span of 36 ft. The ship has an overall length of 45 ft. and an overall height of 14 ft. Its service ceiling is above 50,000 ft., and its combat radius is more than 500 nautical miles. The prototype, the YF-100, made its first flight on May 25, 1953.

• **Piasecki Helicopter Corporation.** . .The Air Force's new helicopter, the YH-16 Transporter, made its first flight on October 13. This flight, which lasted for 12 min., climaxed 6 weeks of ground testing.

• **Pratt & Whitney Aircraft Division, United Aircraft Corporation.** . .A 50-ton metal altitude chamber, 46 ft. long and 12 ft. in diameter, was recently added to the jet-testing equipment at the Andrew Willgoos Turbine Laboratory. This chamber, which will be used to test full-scale turbojet and ram-jet engines, as well as their major components under altitude conditions, has been installed in one of three new test cells now under construction and scheduled for completion in mid-1954. Another chamber, identical with the first, is to be delivered for installation in one of the laboratory's other new test cells.

• **J. B. Rea Company, Inc.** . . .A new plant at 1723 Cloverfield Blvd., Santa Monica, Calif., was occupied by the company on October 19. This new brick-and-concrete structure, which contains 22,000 sq.ft. of floor space, houses business and executive offices, and engineering department, laboratories, a large model shop, and equipment for manufacturing.

• **Republic Aviation Corporation.** . .A 31,500-sq.ft. building located at 447 Broadway, Hicksville, L.I., N.Y., has been leased by Republic for 5 years. It will be used as a tool shop.

• **Solar Aircraft Company.** . .A booklet describing two new types of gas-turbine-driven generator sets is now available from Solar's Gas Turbine Contracts Department in San Diego. These units, one rated 14 kw. a.c./d.c. and the other rated

14 kw. d.c., are powered by the Solar Mars gas-turbine engine and were developed primarily for aircraft auxiliary-power uses....An 8-page booklet entitled *Ducting Systems for Aircraft* has been published by Solar. This booklet on pneumatic systems includes tables showing uses of compressed air on turbine-propelled aircraft; requirements of pneumatic systems, and a check list for specifying ducting. Also included are photos of typical ducting assemblies and material covering the design, fabrication, and testing problems of ducting installations.

• **Standard Oil Company (Indiana)**. . .A research laboratory, now being constructed at Seymour, Ind., by the USAF for work on guided-missile and rocket propellants, will be operated by Standard of Indiana.

• **The H. I. Thompson Fiber Glass Company**. . .William E. Winterhalter has been elected Vice-President and General Manager of Thompson. Mr. Winterhalter was formerly Vice-President and Sales Manager of Owens-Corning Fiberglas Corporation's Pacific Coast Division.

• **Westinghouse Electric Corporation**. . . D.c. aircraft motors for booster pumps, now being built by Westinghouse, measure 5.25 in. in diameter, weigh 37.25 lbs., and deliver 3.75 hp. at 42,000 ft. These fan-cooled motors with aluminum-wool flame suppressors and radio-noise filters are said to be able to drive booster pumps for the hydraulically operated controls of large military aircraft....A new constant-current reference for a Magamp regulator for narrow-speed-range aircraft alternators has been developed by Westinghouse. A magnetic amplifier and entirely a static device, the reference is made up of magnetic devices, a dry-plate rectifier, and similar static components. It occupies a volume of about 24 cu.in....A 16-page summary of equipment available for use in the electronics industry is now available. This booklet, *B-6093*, includes descriptions, applications, and operating ranges for such equipment as surge comparison testers, portable balancers and vibrographs, magnetic amplifiers, transistors, capacitors, relays, etc. . . .William A. Patterson has been elected to the Westinghouse Board of Directors. Mr. Patterson is President of United Air Lines, Inc.

Meet Your Section Chairman

Douglas Andreoli

Texas Section

Douglas Andreoli, Assistant Project Engineer with Chance Vought Aircraft Division of United Aircraft Corporation, was born in Ayr, Scotland, on November 15, 1917. He attended Scottish secondary schools — namely, the Ayr Academy from 1924 to 1934 and the Strathallan Academy from 1934 to 1936. In 1936, he matriculated at the de Havilland Aeronautical Engineering College where he majored in Design (Aircraft), Design (Aero-Engines), and Applied Mathematics. He was graduated from de Havilland with an Engineering Diploma in 1939. He then gained an Associate Fellowship in the Royal Aeronautical Society.

Between 1937 and 1940, he was a member of the Royal Air Force's Auxiliary Air Force Squadron. However, in 1940, he was transferred to the Royal Navy and by 1946—the year of his discharge—had risen to the rank of Lieutenant Commander (a) RNVR. (He is a Service Pilot and Engineering Pilot.)

His 6 years in the Royal Navy were definitely eventful. His first assignment was aboard the H.M.S. "Ark Royal" as Air Engineering Officer. Eighteen months later, this ship was torpedoed and sunk in the Mediterranean some 35 miles out of Gibraltar. Mr. Andreoli says that on this occasion he "didn't even get his feet wet." Some months later, he was serving on the H.M.S. "Audacity" as Air Engineering Officer, Staff, Admiral, Commanding Force "H," when she was hit by four torpedoes and sunk in heavy seas. During the hour that he was in water, the temperature of which was about 30°, he swallowed a considerable amount of salt water mixed with fuel oil. This resulted in his being hospitalized for approximately 1 month.

After recovering from the effects of submersion and fuel oil, he was sent to Washington, D.C., and assigned to the British Embassy and British Air Commission. For the next 2-year period, he did liaison work with the U.S. Navy and aircraft manufacturers. It was during this time that he met and married an American girl, Betty Lyons, whom he had to leave behind when he was assigned to the Directorate of Aircraft Maintenance and Repair, Admiralty, London. During this London tour of duty, he wound up too close to an exploding V-1 German missile and once again found himself hospitalized, this time with severe internal and head injuries.

In due time, Mr. Andreoli recovered from the injuries inflicted by the exploding missile and was given experimental work to conduct on the British Firebrand airplane. He was ultimately sent to Ceylon where he served as Assistant Director of the Naval Aircraft and Repair Yard at Trincomalee. In his last assignment before his discharge, he was attached to the Naval Occupation Forces in Singapore, Federated Malay States.

In 1946, he emigrated to the United States and was at last able to join his wife. In August of that year, they moved to Texas where he began his present association with Chance Vought. Starting there as a Flight Test Liaison Engineer, he was successively given the positions of Development Engineer, Assistant to the F7U-1 Project Engineer, Acting Assistant Project Engineer on the F7U-3, Assistant Project Engineer on the F7U-3, and Assistant Project Engineer on the A2U-1.

Mr. Andreoli, who became an American citizen in March of 1952, enjoys horseback riding and a good game of golf or bridge. He and his wife and their three daughters—Phyllis Mary, aged 9, Allison Patricia, aged 5½, and Jacquelyn Marvis, aged 1—reside at 4064 Rochelle Drive in Dallas.

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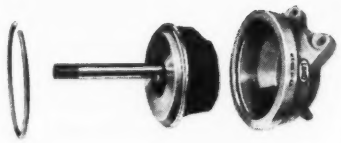

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IAS Sections

Atlanta Section

Edith Hall Lively, *Secretary*

The October 6 meeting was held in the Georgia Tech Dining Hall, with Chairman George K. Williams presiding. The officers of last year were commended for their good work in the interests of the Institute, new members were welcomed into the Section, and the Committee Chairmen for the new term were introduced. The question of a possible Graduate Degree Program under the auspices of Georgia Institute of Technology, which had been introduced at the previous meeting, was discussed further. It was decided to table it until the next quarter.

Ex-Chairman George Baughman introduced the speaker of the evening, W. R. Rhoades, Military Research Development Liaison Engineer, Lockheed Aircraft Corporation, who is stationed in Washington, D.C. Mr. Rhoades's theme was "Weapons System Concept of Aircraft Design, Manufacturing, and Procurement."

Mr. Rhoades prefaced his talk with recent quotations from military, scientific, and political authorities which demonstrated the necessity of faster development of battle-ready air-borne weapons. Costly lessons of World War II and the Korean operation resulted from the lack of long-range planning and technical development required to ensure combat readiness and technical superiority of our aircraft.

A progressive attack on the problem began during the latter part of World War II and became known as "Weapons System Design." It assumes that the aircraft is simply one of a group of several components, each of which must be designed as an integral part of a complete system. Such a system normally consists of the weapons, equipment, aircraft, and crew, together with the ground-based facilities and personnel required for the sustained performance of the mission.

While the aircraft industry recognized the Weapons System to be good, it has been rather slow in exploiting its advantages. Contributing reasons stemmed from uncertain and drastically reduced procurement at the end of World War II, lack of understanding by some of the military, dissolution of many outstanding man-power teams at the end of the war, and vacillating national policies with regard to strategic armament and defense policies. In addition some segments of the aircraft industry have been reluctant to assume the new responsibilities that the Weapons System would bring.

Regardless of the deterrents, a number of companies have activated departments whose job is to design Weapons Systems. The complexity of the missions, the multiplicity of possible agents of accomplishment, and the long manufacturing lead times further divide the System approach into "Operations Research" and "Long-Range Development Planning."

"Operations Research" provides a quantitative basis for the selection of the optimum weapons systems required to perform each particular mission. "Long-Range Planning" ensures that combat-ready weapons systems are made available to the operating commands at the time and in the quantity needed.

The Weapons System designer has a much more complex and difficult problem than the design of one of the major components, since his design must deliver the optimum in integrated weapons from a complex and diversified selection of major components. Erroneous decisions at this time may cost millions in dollars and years in time.

In spite of these difficulties, procedures are evolving which are yielding results. Briefly stated, they are as follows:

(1) Determine the need for an "Operations Research" study. Become thoroughly conversant with the problems of the operating command, selecting only those problems for which there is real need.

(2) State the problem. Careful definition of the objectives and scope of the study prior to beginning actual work is essential.

(3) Collect basic data. Collect and compile data describing the important physical characteristics, performance, and capabilities of the weapons, equipment, power plant, and other components and subsystems which merit consideration in the study, together with a prediction of their development trends.

(4) Determine the characteristics of the opponents. Study all available intelligence data concerning enemy characteristics and capabilities.

(5) Determine the measures of effectiveness. Set up mathematical models that clearly define the relationships between the various factors in the problem. Determine the sensitivity of the result to variations in each perimeter.

(6) Synthesize the spectrum of possible solutions. Formulate families of weapons systems by combining the various components and subsystems in all possible ways.

(7) Evaluate and compare. Using the measures of effectiveness, determine the index of efficiency for each possible solution in carrying out the required strategies and tactics.

After the "Operations Research" is completed, the following steps are taken: (1) re-evaluation of requirements by the military; (2) assignment of the development to a single prime contractor wherever possible; and (3) careful control of the development by all concerned.

The meeting was concluded with the showing of Shell Oil Company's motion picture, *The History of the Helicopter*.

Baltimore Section

R. W. Sanford, *Secretary*

The forty-fifth meeting of the Baltimore Section was held in Maryland Hall at The Johns Hopkins University on October 8 at 8:30 p.m. There were approximately 100 members and guests present.

The speaker was Brig. Gen. Floyd B. Wood, Deputy for Development, Air Research and Development Command, Baltimore, Md. His subject was "Research and Development as a Factor in Military Strength."

General Wood opened his talk with a history of weapons, starting with the cave man and progressing through the Air Force's experience with World War II aircraft. The moral of this discussion was to the effect that no specific weapon can be developed beyond a certain stage. After each weapon has reached its limit, it must be supplanted by another weapon or new techniques. Generally speaking, these new weapons and techniques can only be made available by an increase in basic knowledge; hence, the importance of research and development.

General Wood next considered the problem of how the Air Force decides what weapons to build. In this connection, he pointed out that it is necessary to know who and where we expect to fight and what equipment the potential enemy possesses. Since weapon techniques cannot exceed our basic know-how, it is essential to evaluate each proposed weapon in the light of available technical knowledge and how this knowledge can be applied. If a weapons system cannot be made practical without development of new techniques, additional research must be accomplished before the Air Force will undertake its development. Weapons problems are assigned to the Research and Development Command by Headquarters USAF. The Research and Development Command in turn takes these problems to industry and science for solution. Proposed solutions are evaluated in terms of the promise of effectiveness shown and the economics associated with development and utilization. After evaluation a development

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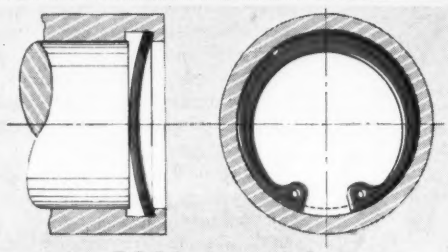

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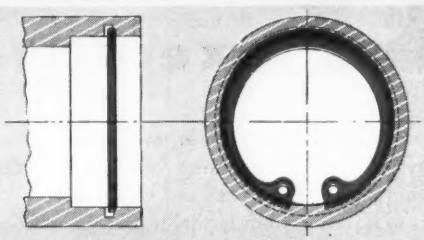

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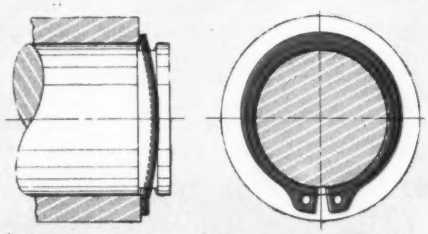

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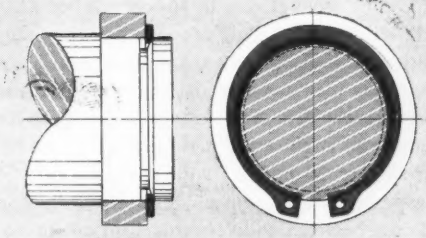

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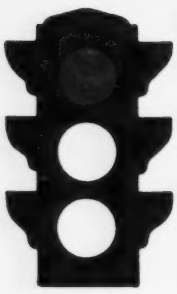

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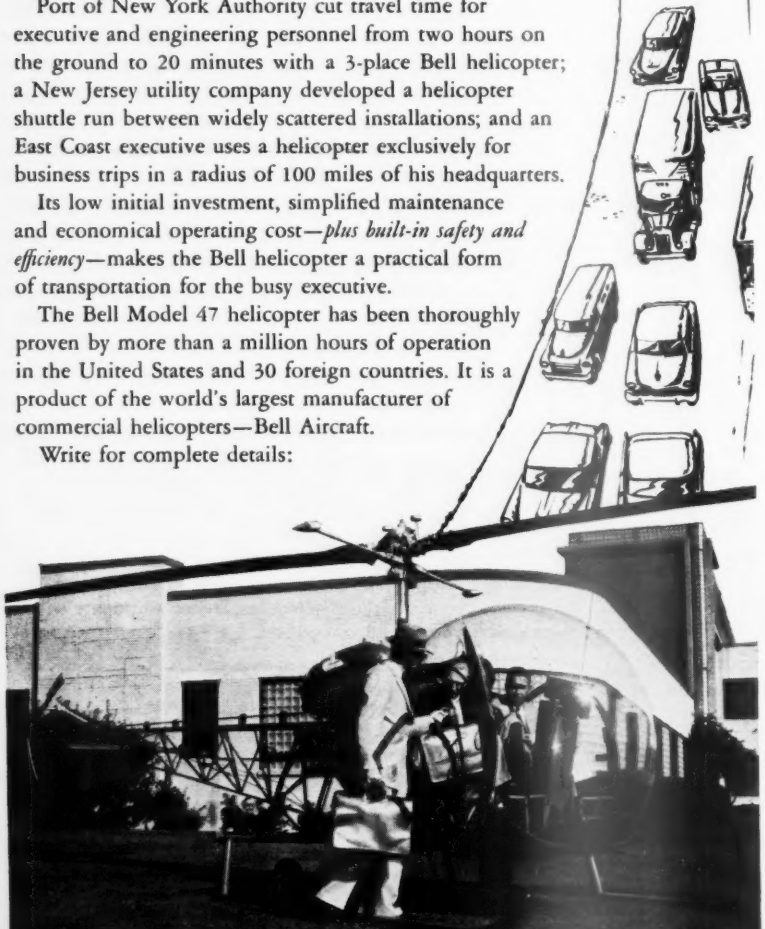

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plan for new weapons is drawn up and is then presented to Headquarters USAF for approval.

The development plan must be complete, balanced, integrated, and timely. It contains a general design and development specification that is turned over to industry for execution. In carrying out the development job, the Air Force may or may not assume responsibility for subsystems that are a part of the major weapons system. In any case, military advice and assistance required for the development will be made available to industry by the Air Force wherever possible.

General Wood concluded his discussion with a statement of requirements for military superiority over the long pull. The first requirement is a "force in being." We must have military personnel and equipment available for retaliation against any attack. However, it is impossible to anticipate completely the direction and magnitude of potential attacks, and thus it is economically impossible to prepare for all contingencies. A balanced force, therefore, is one that will deter the enemy by a knowledge of certain retribution rather than a dollar-for-dollar division between Army, Navy, and Air Force facilities. The second requirement is production capacity. Tools must be available, as well as engineering organizations. A strong basic and applied development program must be practiced in peacetime. It was emphasized that this does not mean quantity production of today's weapons inasmuch as they are continually becoming obsolete.

Following General Wood's talk, an interesting movie was shown depicting the Air Force's part in atom bombing tests in Nevada.

Buffalo Section

George Melrose, *Vice-Chairman*

The following persons were elected to office: Chairman, William Champney; Vice-Chairman, George Melrose; Secretary, Alison Arnold; and Treasurer, Robert Goldin. The Advisory Board is composed of Richard Frost, Richard Koegler, Alexander Krivetsky, and Dexter Rosen. Dr. E. T. Welmers is the Representative to the Nominating Committee for Area Councilor.

Chicago Section

Leland W. Sims, *Secretary*

On Wednesday, November 4, the Chicago Section met at the Globe Corporation, Aircraft Division, in Joliet, Ill. At 6:30 p.m., a Globe-sponsored buffet supper was served to 172 members and guests. After dinner, several groups who had not previously visited

the plant were conducted on a tour of the shops where radio-controlled target drones are produced for the U.S. Navy.

At 8:00 p.m., the group assembled for the meeting and was called to order by Alfred F. Stott, Chairman. Mr. Stott then introduced Dr. Harold V. Hawkins, Director of Engineering of the Aircraft Division, who welcomed all to the Globe plant. Dr. Hawkins then introduced W. S. McAdoo, General Manager, Aircraft Division, who welcomed all as guests of the Globe Corporation.

Chairman Stott then introduced Charles L. Bonnette, Vice-Chairman of the Section and Chairman of the Program Committee who described the evening's program and introduced the speakers. Three speakers collaborated on the general subject of "Chicago Area Defense," each describing one activity of the three cooperating branches of air defense.

Lieutenant Colonel Donald F. Armstrong, Illinois State Ground Observer Corps Coordinator, described generally the air-defense organization, which consists of the Ground Observer Corps, Chicago Filter Center, Air Defense Control Center, and the Anti-Aircraft Units. Colonel Armstrong graphically illustrated the alerting of the various branches of air defense by the approach of a hypothetical enemy bomber. The need for civilian ground observers was also stressed for detection of planes flying below 5,000 ft. Colonel Armstrong described in detail the function of the Air Defense Control Center and the key point air raid warning network that protects large industrial and populated areas.

Major General E. Hallas, Director, Operations and Training Section, 4706 Defense Wing, O'Hare Field, was then introduced and described the active air defense showing the function of the interceptor squadrons in contacting unknown aircraft and the manner in which pilots are alerted for this mission. Major Hallas described the general organization of the Air Defense Command and the various regional boundaries.

Lieutenant Colonel Lee H. Burnham, Operations Officer, 45th Brigade, Anti-Aircraft Artillery, Fort Sheridan, was then introduced to explain the function of the antiaircraft artillery in the air-defense organization. Colonel Burnham gave a brief history of the development of the Army Air Defense, which was organized in 1950. He traced the growth of this branch from the early Harbor Defense and Coast Artillery to the present Air Defense Corps. Colonel Burnham described in detail the organization and function of an anti-aircraft unit and the manner in which it is coordinated with the other air-defense branches.

The program was concluded by a film entitled *Air Defense*, which showed the participation of a civilian ground observer in the detection of an enemy bomber.

Chairman Stott closed the meeting with the reminder of the next meeting on December 17 at the Sheraton Hotel.

This December 17 meeting commemorated the Fiftieth Anniversary of Powered Flight.

Dayton Section

W. Donald Dodd, Jr., *Secretary*

The fall season was opened with a successful dinner meeting held at Cordel's Supper Club on October 29. The program included the installation of the new officers and presentation of "past-chairman keys" to William S. Barden (1953) and to Lt. Col. Floyd Sweet (1952). As Colonel Sweet, now stationed at the Pentagon, was unable to attend the meeting, his key was sent to him.

The speaker was Brig. Gen. W. A. Garland, Commander, Air Technical Intelligence Center, Wright-Patterson AFB, Ohio. His subject was "The Flying Exhibit and Display of the Society of British Aircraft Constructors at Farnborough, England." General Garland showed movies and slides which he took at the air show and thus gave the local members an excellent review of the latest British aircraft. An interesting discussion followed the talk.

Hagerstown Section

George W. Westphal, *Secretary*

The 1953–1954 series of meetings of the Hagerstown Section was opened with a dinner meeting on September 23 at the American Legion Club. The number of members and guests present totaled 48. Officers installed for the coming year were: Chairman, R. A. Darby; Vice-Chairman, T. H. Beck; Secretary-Treasurer, G. W. Westphal; Advisory Council, H. C. Billings, J. A. Clopper, R. W. Lessard, E. E. Morton, and R. H. Ziegenfuss; and Representative to Area Nominating Committee, R. D. Gilson.

Mr. Billings opened the meeting and expressed his appreciation to the retiring officers for their cooperation during the preceding year; to the Program Committee for their scheduling of a fine series of programs; to the Membership Committee whose efforts increased the total Section membership during the year by approximately 50 per cent; to the Nominating Committee; to those committees and individuals who participated in banquet arrangements; and to all others who worked to make the year a successful one.

Henry Weisenberger gave a report of the preceding year's activities and a financial statement for the Section.

In the unavoidable absence of most of the newly elected officers, Mr. Gilson spoke on their behalf in accepting the responsibilities as officers of the section for the coming year.

Mr. Billings introduced the speaker for the evening, Dr. Karl Cohen, Vice-President of Walter Kidde Nuclear Laboratories. Dr. Cohen spoke on the subject of "The Atom and the Airplane." His topic covered only those aspects that were of an unclassified nature. He gave a brief résumé of the development of the laboratory with which he is associated. He discussed some of the aspects of the atom and hydrogen bombs and compared the energy levels of hydrogen and uranium reactions. He also gave a comparative analysis of these energies with those of commonly used combustible fuels on a relative basis per unit of energy. Dr. Cohen discussed some of the problems involved in the use of a nuclear power plant for aircraft, one of the greatest of which is the extremely large ratio of power-plant installation weight to airplane gross weight. Much of this excessive weight results from the shielding required to protect passengers and crew.

The talk was concluded with a question-and-answer session.

▶ The October 12 meeting was held in the Packet Room of the Terrace Restaurant in Hagerstown, Md. Chairman R. A. Darby presided. Twenty-three members and guests were present.

Mr. Billings gave a report on the plans for the November meeting. It was voted unanimously to hold this meeting at the Hotel Alexander in Hagerstown.

Mr. Darby announced the appointment of the following committee chairmen: Program Committee, R. E. Eisiminger, Jr., and Membership Committee, J. A. Neilson, Jr.

Mr. Lessard introduced the speaker for the evening, J. A. Shortal, Chief, Pilotless Aircraft Research Division, NACA, Langley Field, Va.

Mr. Shortal outlined some of the activities at Langley Field in a most interesting and informative talk, which was illustrated by motion pictures and slides covering some Wallop's Island activities on rocket-propelled model testing. He discussed some of the problems, the use of various types of telemetering equipment, and some of the results of the testing activities. The talk was concluded with an interesting question-and-answer session.

Los Angeles Section

Harold S. Fischer, *Secretary*

Lester Lees, Assistant Professor, California Institute of Technology, ad-

dressed the Specialist Meeting of October 8 on "Recent Research on Viscous Effects at Hypersonic Speeds." He presented experimental data showing that the extreme build-up of viscous layers in hypersonic flow changes the effective body shape and induces pressure changes.

▶ On October 15, the monthly dinner meeting had as its feature a panel discussion on the general subject of automatic controls in aircraft. The panel consisted of: Dr. C. Stark Draper, Professor and Head, Department of Aeronautical Engineering, and Director Instrumentation Laboratory, Massachusetts Institute of Technology; Ben O. Howard, Aviation Consultant and Engineering Test Pilot; Dr. Arthur L. Klein, Associate Professor, California Institute of Technology, and Consultant, Douglas Aircraft Company, Inc.; John R. Moore, Assistant Director, Electromechanical Engineering Department, North American Aviation, Inc., and Visiting Associate Professor, Department of Engineering, University of California at Los Angeles; Robert J. Shank, Head, Radar Laboratory, Hughes Aircraft Company; Dr. James B. Rea, President, J. B. Rea Company, Inc.; Edgar Schmued, Vice-President in Charge of Engineering, Northrop Aircraft, Inc.; and Brig. Gen. Leighton Davis, Assistant for Development and Supporting Research, Headquarters, ARDC, USAF.

Section Chairman Harold Luskin presided, and an audience of over 300 attended. The discussion was lively and touched on many phases of the automatic control problem, including weight, reliability, safety, complexity, etc. One of the main points brought up was that a more important compromise than that between complexity and simplicity was that between performance and reliability. It was also strongly pointed out that before anything else was considered the need for automatic control had to be proved. There was considerable discussion from the floor later in the meeting.

▶ "The Elastic Stability of Skew and Triangular Plates" was discussed by Dr. W. H. Wittrick, Senior Lecturer in Aeronautics, Sydney University, Australia, at the Specialist Meeting on October 22. Dr. Wittrick has been associated with Hawker Aircraft Company, Engineering Laboratory at Cambridge, and the Royal Aircraft Establishment at Farnborough. His paper was concerned primarily with the critical stresses of flat skew plates under compression and sheer, related to problems in swept-wing panels of parallelogram shape.

▶ The theme of the October 30 Social Mixer event held in the Los Angeles IAS Building was Halloween. A pleasant evening was enjoyed, with dancing, games, costume prizes, and refreshments.

▶ Members of the Los Angeles Section have had the opportunity of participating in an inspection tour of the U.S. Naval Air Station at Los Alamitos, Calif. Tours were arranged on four successive Saturdays, October 24 through November 14. Visitors were shown the radar laboratory, armament shop, airplane and helicopter servicing facilities, flight operations office, flight training, parachute loft, Link trainer operation, and the control tower and were given demonstrations of airplane and helicopter flights.

Montreal Section

Gordon Rosenthal, *Secretary*

The many difficulties facing airmen navigating through the polar regions were related by S/L K. R. Greenaway, RCAF, on November 2 at Loyola College Auditorium. The speaker was recently awarded the McKee Trophy for his contributions to the advancement of Canadian aviation throughout the past year. He has also won worldwide recognition as an authority on arctic navigation.

The speaker was introduced by S/L E. McCullough, RCAF. The address

was titled "Some Problems of Air Operations in the Canadian Arctic." Slide illustrations that accompanied the talk showed navigation systems and arctic terrain under visual contact and by radarscope observations.

Squadron Leader Greenaway outlined the main problems of arctic operations as: (1) magnetic phenomena; (2) direction definition; (3) lack of accurate charts; and (4) lack of weather information.

Under magnetic phenomena, there is the limitation of having approximately 1,000,000 square miles of Canada within a region of weak horizontal components of the earth's magnetic field. In this region, large and erratic corrections to magnetic compasses are required, particularly during magnetic storms. Arctic navigational systems, therefore, do not rely on magnetic compasses.

Rhumb-line and great-circle courses are no longer used. The grid technique first suggested in 1927 by an Italian Navy Admiral has been adopted. The grid method permits a better heading definition on the special polar plotting charts.

Only in recent years has a proper mapping of the polar regions been attempted. Several examples of polar charts were displayed at the meeting.

Arctic weather information has now become more available and reliable. Couple this with the fact that arctic upper air winds are relatively low, and it follows that weather no longer presents any major obstacles.

Numerous electronic aids have been introduced, which must of necessity be wholly contained within the aircraft. The inaccessibility of the arctic terrain makes it difficult to provide ground radio-range stations; terminal marker beacons, however, are possible.

Use has been made of free gyros for defining flight headings. Gyro reference directions are set by astro observations or by relating the gyro to known directions, as for example a runway heading or the bearing of certain topographic features.

Radarscope patterns of arctic terrain and ice and water are often confusing and can be interpreted properly only after considerable experience. Visual recognition of features on the ground is also difficult because of the presence of low clouds and fog and the lack of contrast in the features.

Mention was made of the difficulties in setting up arctic air bases. This was attributed mainly to ground frost effects on runways. The possibility of sea fog prohibits the establishment of bases near bodies of water.

A brief question period followed the talk. The speaker was then thanked by R. H. Guthrie, and the meeting was closed.

St. Louis Section

G. S. Graff, *Secretary*

The following officers were elected by mail ballot for the 1953–1954 season: Chairman, John H. Meyer; Vice-Chairman, Allan W. McCoy; Secretary, George S. Graff; and Treasurer, Paul R. Des Jardins. The Advisory Board is made up of Kendall Perkins, David S. Lewis, Carl J. Wenzinger, and Vernon Outman. Committee Chairmen are as follows: Program, Lawrence K. Edwards; Membership, Charles M. Forsyth; Publicity, Innes Bouton; Educational, C. Donald Lundergan; Professional Activities, Herbert R. Grumman; and Nominating, W. L. Wells.

▶ The first meeting of the new year was held on September 23 and was a panel discussion on "Automatic Control." Panel Moderator was Kendall Perkins, Vice-President of Engineering, McDonnell Aircraft Corporation. C. S. Draper, Director of Instrumentation, Department of Aeronautical Engineering, Massachusetts Institute of Technology, spoke on "The Philosophy of Automatic Controls in Flight"; David Whitcomb, Head, Aeronautical Engineering Flight Research Department, Cornell Aeronautical Laboratory, spoke on "The Automatic Stabilization of

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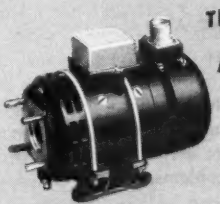

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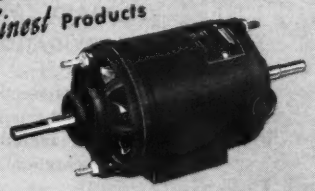

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Airplanes"; and B. G. Bromberg, Chief Engineer, Missiles Engineering Division, McDonnell Aircraft Corporation, concluded the discussion with a talk on "Automatic Control of Other Airplane Functions Including Fire Control."

▶ The second meeting of the year was a Field Trip on October 24, with one group visiting McDonnell Aircraft Corporation and the second group visiting Scott AFB. Both groups met later at the Anheuser-Busch plant for a social meeting and lunch.

San Diego Section

H. C. Matteson
Corresponding Secretary

The October activities of the San Diego Section were featured by two interesting and informative technical meetings. Both meetings were well attended. The San Diego Section technical meeting program of the past year has met with enthusiastic response from the membership, and plans are being laid to provide an even greater program for the coming year.

▶ A paper entitled "A Discussion of the Development, Experience, and Design Problems Associated with Several Types of Variable-Area Exit Nozzles" was presented on October 1 by J. S. Winter and R. G. Laucher, of Marquardt Aircraft Company. This paper was originally given at the IAS Annual Summer Meeting and was published in the September issue of the AERONAUTICAL ENGINEERING REVIEW. Approximately 60 persons were in attendance at the meeting. Wide interest in this comparatively new field was shown by the extent of the informal discussion during the question-answer period. Following an established practice, coffee and doughnuts were served at the close of the prepared talks.

▶ "Operations Research" was the title of an informative talk jointly presented on October 29 by A. Burstein and J. M. Pasternack, of Convair, San Diego. Mr. Burstein is Convair's Chief of Systems Analysis, and Mr. Pasternack is the Operations Analysis Group Engineer. By virtue of their background and position, they were especially well suited to discuss this new branch of applied sciences. The meeting was well attended, with 105 persons present.

Mr. Burstein defined the subject and reviewed its historical development, noting that it first came into wide use by the military services during World War II. He pointed out that the prime purpose of operations research is to provide executive departments, both military and civilian, with the best possible quantitative basis for decisions on operations under their control. This is especially important in the aircraft

field where the development of complex equipment demands great lead time and a consequent need for quantitative evaluation of such equipment prior to actual proof testing.

Mr. Pasternack discussed typical practical problems for which the operations analysis engineer must provide quantitative data. The nature of this work was well illustrated by describing the means by which the merits of several combinations of guidance systems, interceptor aircraft, and armament might be quantitatively compared with regard to their overall effectiveness in the aircraft interception problem.

A lively discussion period followed the prepared talks. The application of this type of engineering to the solution of a wide variety of practical problems such as the highway traffic-accident rate, was discussed freely by both the speakers and the audience. The meeting was considered highly successful.

Seattle Section

Alvin J. Jarvis
Outgoing Secretary

The meeting of October 21 was held at the Sand Point Naval Air Station. As is usual for Seattle Section meetings held at this facility, the evening began at 6 p.m. with a social hour, and members and their guests gathered in groups in the lounge.

Dinner was served at 7 p.m. in the dining room where the remainder of the meeting was held.

The speaker of the evening was A. M. (Tex) Johnston, Chief of Flight Test, Boeing Airplane Company, who spoke on the various aspects of flight testing to obtain engineering data.

Mr. Johnston, 37-year-old Kansan with close to 9,000 hours of flight time behind him, got his nickname during his barnstorming days in the early 1930's. At that time, he acquired a lasting fondness for cowboy boots, while barnstorming throughout the Midwest and Southwest.

He served as Flight Instructor for the U.S. Army Air Corps and as a Ferry Pilot for the Air Transport Command before joining Bell Aircraft Corporation in 1942. In July of 1949, he joined Boeing as Project Pilot for the B-47 Stratojet. It was he who was at the controls of the Boeing YB-52 when it made its inital flight.

Mr. Johnston was the first to take up the RP-63 King Cobra fighter, the TP-39 Airacobra fighter trainer, the V-tail P-63, and the Navy's L-39, which was the first experimental swept-wing airplane in the United States. He was also one of the first men to fly the Bell X-1.

Mr. Johnston spoke on the problems encountered in programing test flying and in instrumenting an airplane to provide the maximum flight condition data for a given series of tests.

His talk encompassed problems to be encountered in coming years as man extends his horizons to higher altitudes and Mach Numbers. He showed how flight testing is doing its job to provide the customer with a better product by exploration of all conditions of flight. His talk bore out the thought behind the motto that hangs on the wall in the Boeing Flight Test Office—"One test is worth a thousand expert opinions."

▶ The officers for 1953–1954 were installed at the November 18 meeting. They are: Chairman, G. E. Ledbetter; Vice-Chairman, V. M. Ganzer; Secretary, R. B. Light; and Treasurer, J. C. Baer.

Tullahoma Section

Robert W. Kamm
Outgoing Secretary

The first formal meeting of the Tullahoma Section was held on October 6 at the Southern Queen Restaurant. Twenty-one members and thirteen guests were present.

Temporary officers, who had been elected at the organizational meeting on January 23, presided. These were: Joel Ferrell, Jr., Chairman; Raymond Schneyer, Vice-Chairman; Robert W. Kamm, Secretary; and Hugh E. Gardenier, Treasurer. The Chairman pointed out that, although meetings had been held on March 18 and June 9, the temporary officers considered them informal and that the present meeting was considered the first formal meeting.

The main event of the meeting was an interesting talk by John Wild, Director of Engineering of ARO, Inc., regarding his recent trip to England. Mr. Wild stated that his trip had been a multi-purpose one. The primary reason was to attend a meeting of the Advisory Group for Aeronautical Research and Development of NATO as a member of the Wind Tunnel Panel of that organization. While there, he attended the Fourth Anglo-American Conference in London and the SBAC Flying Display and Static Exhibition at Farnborough.

The main part of his talk dealt with the Farnborough show. He presented a large number of excellent colored slides of photographs he had taken of various airplanes on exhibition, which included helicopters, piston-engined cargo planes, turboprop transports, and turbojet fighters and bombers. Mr. Wild pointed out many interesting design features of each airplane displayed. In describing one of the bombers, he noted that a paper presented at the Anglo-American Conference regarding the desirability of the Boeing pod-type engine installation as opposed to the British submerged engine installation had promoted considerable discussion. Without attempting to defend either position, he noted that, whereas Boeing prefers to carry fuel, bombs, etc, internally and the engines externally, the British seem to favor internal installation of the engines and the use of external stores for additional fuel, etc.

Of particular interest was Mr. Wild's statement that the British were pushing foreign sales of their aircraft on the basis that the profit involved in such sales was higher than practically any other commodity they can produce.

Following a brief question-and-answer period, a short business meeting was held. The Chairman of the Nominating Committee presented nominations for officers, and his nominations were adopted by voice vote. The officers elected are: Donald R. Eastman, Jr., Chairman; E. M. Howard, Vice-Chairman; J. D. Gray, Secretary; and C. J. Schueler, Treasurer. Members of the Advisory Board who were elected are: Joel Ferrell, John Wild, Robert Kamm, Gaylord Newton, Ronald Smelt, and Bernard Goethert.

Washington Section

T. C. Muse, *Secretary*

The Washington Section held the first meeting of the 1953–1954 season the evening of October 12.

After a highly successful dinner and social hour at the Burlington Hotel, the technical portion of the meeting, covering the 1953 SBAC Show and the joint IAS-RAeS conference, was held at the Museum of Natural History of the Smithsonian Institution.

Captain W. C. Fortune, USN, Chairman of the Washington Section, introduced Rear Adm. Apollo Soucek, USN, Chief, Bureau of Aeronautics; Prof. Willy Messerschmidt, the German aircraft designer; and Hans Multhropp, Head, New Design, The Glenn L. Martin Company. The local officers were then introduced, and a general outline of the meeting plans for the coming year were presented. The meeting was then turned over to the guest Chairman, Rear Adm. C. M. Bolster, USN, Chief of Naval Research, Navy Department.

Dr. Hugh L. Dryden, Director, National Advisory Committee for Aeronautics, the first speaker of the evening, covered the joint IAS-RAeS meeting. The IAS-RAeS meeting was quite popular, with approximately 700 people in attendance. Of this, 150 were Americans. Dr. Dryden summarized briefly the technical material presented at the meeting and noted some of the less technical but interesting features.

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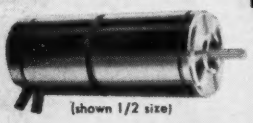

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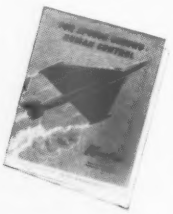

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He thought the caliber of the papers was exceedingly high and that Dr. Hoff's Wilbur Wright Memorial Lecture was especially noteworthy. It was also of interest that the Americans participated more actively in the discussions than they had in previous sessions.

Rear Admiral L. B. Richardson, USN (Ret.), Vice-Chairman of the Boards of Canadair Limited and Consolidated Vultee Aircraft Corporation, the second speaker, discussed his impressions of the individual aircraft and exhibits at the SBAC Show. He pointed out that the show is a demonstration of the quantity of British aircraft and is held primarily to promote their sale. The aircraft of principal interest was the Handley-Page "Victor" bomber, which completed the "V" Series (Vickers "Valiant," A. V. Roe "Vulcan," and Handley-Page "Victor"). Admiral Richardson told about a demonstration in which an observer riding in the Victor describes a hands-off landing. He commented that, while the observer described the operation adequately, there were instances when his voice sounded a trifle strained. As has been true at previous shows, the flying demonstrations were superb.

In addition to the SBAC Show, Admiral Richardson described the SBAC dinner at which 92 nations were represented. Apparently the preparation and prompt serving of 1,000 grouse to 1,000 guests was an achievement comparable to advances in aircraft development and equally impressive.

Lieutenant General L. C. Craigie, USAF, Deputy Chief of Staff, Development, continued in providing general comments and details of the aircraft exhibits and illustrated his discussion with the showing of some excellent colored slides he had taken of the aircraft.

S. Scott Hall, Head, Technical Services, British Joint Services Mission, gave a brief history of the SBAC Show. He stated that the first show was held in 1931 and that the 1953 show, the fourteenth in the series, was regarded as representing a year of consolidation.

Rear Admiral Robert S. Hatcher, USN, Assistant Chief, Bureau of Aeronautics, added his impressions of the SBAC Show to the previous comments. He also commented on his visits to British aircraft manufacturers.

Student Branches

Indiana Technical College

Forest R. Straub, *Secretary*

The meeting of September 22 was called to order at 8:15 p.m. by Chairman Olmstead. The business of the meeting

was the election of officers, which gave the following results: Chairman, John Wright; Vice-Chairman, Leroy Dimmick; Secretary, Forest Straub; and Treasurer, Howard Hall. The meeting was adjourned at 9:00 p.m.

▶ The October 6 meeting was called to order at 8:05 p.m. by the presiding Chairman John Wright. The minutes of the last meeting were read by the Secretary and were approved as read. The meeting was then opened for the current business.

A motion was made and seconded that the usual banquet be postponed until next term in favor of a field trip for this term. Motion carried.

It was suggested that two places be visited on the field trip—namely, Wright-Patterson AFB in Dayton, Ohio, and Aeroproducts Operations, Allison Division, General Motors Corporation. The Secretary was asked to correspond with the two named places and inquire about the availability of the last Friday in October and the first Friday in November.

A report on the committees was then given by their respective chairmen.

After the business meeting, which was adjourned at 8:25 p.m., Roland Boucher gave an interesting talk on Canada and its people.

▶ The meeting of October 20 was called to order by Chairman Wright. The minutes of the last meeting were read by the secretary and approved as read.

The Secretary then gave his report on the proposed field trip to Aeroproducts and Wright-Patterson AFB. The answer from Aeroproducts revealed that, because of security restrictions, the visit could not take place. A letter from Wright-Patterson said that November 13 was available and that the group could have either the all-day tour or the half-day tour. It was decided to accept the half-day tour and that the group should leave for Dayton no later than 7:00 a.m. The Secretary was asked to inquire about the price of chartering a bus from ABC Coach lines.

Mr. Dow announced the summer-term winner of the Outstanding Student Award as Richard Brown.

The meeting was adjourned at 8:30 p.m., after which Elwood Krout gave a talk on Grandpa Pettibone.

Parks College of Aeronautical Technology

Myron Tygar, *Recording Secretary*

The following student officers were elected at the September 28 meeting: Chairman, Frederic Weisman; Vice-Chairman, John A. Albertini; Treasurer Max D. Beasley; Recording Secretary, Myron Tygar; Corresponding Secretary Merle J. Denny; and Librarian, Lloyd D. Gish.

The Pennsylvania State University

Ralph N. Straley II, *Secretary*

The first scheduled meeting of The Pennsylvania State University Student Branch was held on September 30 on the Penn State campus with 70 Aeronautical Engineers attending. Frank Leader, Chairman, presided.

Chairman Leader welcomed all the old and new students to the first meeting and went on to point out the ideals and aims of the Branch. The remaining student officers were then introduced.

John A. Fox, our Faculty Sponsor, made a brief statement on the awards given for technical papers.

A short film, *Faster Than Sound*, was then shown. This film depicted a miniature pilotless rocket in tests to break through the sonic barrier. The film also showed how the automatically controlled flight was traced by radar.

Refreshments were served after the adjournment of the meeting.

Rensselaer Polytechnic Institute

Janet De Wan, *Secretary-Treasurer*

The first meeting of the school term was called to order on October 28 by Chairman Ronald Harris, who briefly described the IAS, its functions, and the benefits derived from the organization by the student. Mr. Harris outlined the tentative program to be followed for the coming year and then introduced the student officers to the group. Elected last spring, they are: Ronald Harris, Chairman; William Herling, Vice-Chairman; Janet De Wan, Secretary-Treasurer; and Dennis Brundage, Assistant Secretary-Treasurer. Mr. Harris also introduced our Faculty Advisor Dr. J. A. Foa.

Two films were then shown, *The Phantom (Navy XFD-1) Airplane* and *Cavalcade of Aviation*. The former showed several stages in the design of the aircraft and actual ground, carrier, and flight operation of the MacDonald Navy XFD-1 jet fighter. The second film showed the advancement of aviation through the years and some of the freak inventions in the field of aeronautics.

Following the films, a membership drive was started, with 33 men joining the R.P.I. Student Branch. Fifty-five persons were present.

United States Naval Academy

R. M. Hemings, Jr., Midshipman 1/c
Secretary

On November 2, 200 students were present to hear Lt. W. O. Fiske, U.S.N., who is associated with the Navy's polar research work, speak on "Naval Operations in Establishing the Air Base at Thule, Greenland."

In Lieutenant Fiske's interesting talk, he covered the difficulties experienced by the Navy in setting up the Thule air base. He gave a summary of flight and air navigation capabilities in the polar areas, where poor visibility exists, and also discussed the difficulties involved in starting and maintaining aircraft engines in sub-zero climate. This talk, which was illustrated by colored slides, included a coverage of the flight characteristics of turbojet engines in the cold dry air found in polar areas.

Lieutenant E. C. Atkinson, U.S.N., Officer Representative of the U.S.N.A.'s Aeronautical Engineering Club, presided at the meeting.

University of Michigan

Donald E. Wilcox, *Secretary*

The meeting of October 1, with 26 students in attendance, was called to order by Chairman Kirk Comstock. The first item of business was a discussion of summer employment. Those members who had worked in industry this past summer gave their impressions of the companies for which they worked.

Professor W. C. Nelson outlined the coming activities of the Engineering Centennial and Open House, expressing the hope that the members would take an active part in the program.

University of Notre Dame

John Philip Fallon, *Secretary*

The meeting of October 7, the first one of the fall semester, was called to order by Chairman Thomas L. Lindsay at 7:45 p.m. in the Aero Building. Forty-two students were present.

At the conclusion of the business portion of the meeting, Frank N. M. Brown, Professor and Head of the Aeronautical Department at Notre Dame, gave a short talk to the freshmen on the advantages of taking Aeronautical Engineering. He stressed the need for men with an ever growing interest in aviation. Following his talk, the speaker ran various smoke-tunnel tests for the benefit of the freshmen.

A film, *The Avro-Jet Liner*, was shown.

University of Oklahoma

Ernest Z. Anderson, *Secretary*

The meeting of September 23 was called to order by Chairman Jack Lowen with 18 students present. After the Branch officers were introduced, Prof. L. A. Comp spoke on the purpose and advantages of the IAS. This was followed by a talk by Professor Ketcham

who spoke on the facilities and organization of Oklahoma's Aeronautical Engineering Department.

The meeting was concluded with a brief description by Chairman Lowen of the future programs and an announcement of a field trip on September 30 to Aero Design & Engineering Company.

University of Tulsa

William A. Keeler
Secretary-Treasurer

The October 8 meeting was called to order by Chairman Jack Owens with 24 persons present. The minutes of the previous meeting were read and approved. The election of a Vice-Chairman was brought before the members, with Harold Roberts receiving the post.

A possible field trip over the Thanksgiving holidays was discussed and was received favorably by the members. Two possibilities were taken under consideration, one to Wichita, Kan., and the other to Fort Worth, Tex. Jim Kirkpatric was appointed to make arrangements.

Following the business session, a movie was shown on the engineering opportunities offered by Boeing Airplane Company. Three Boeing representatives were on hand to talk to the members and answer their questions.

West Virginia University

Benjamin D. Grove
Corresponding Secretary

The IAS Student Branch at West Virginia University sponsored R. M. Woodham as guest speaker at the monthly meeting of the General Engineering Society on October 27.

Mr. Woodham, Administrator, Cornell-Guggenheim Aviation Safety Center, has been in aviation for 27 years and is experienced in design, installation, and operation of both military and commercial aircraft and engines. His subject on this occasion was "Research in Aviation Safety." Photographic slides supplemented his talk, which was followed by a color film of NACA research on crash-landing fires.

Our deepest appreciation goes to Mr. Woodham for an excellent presentation of the behind-the-scenes research in aviation safety.

Following the general meeting, the IAS members held an informal discussion with Mr. Woodham on some of the more outstanding developments in the aviation-safety field.

Members Elected

The following applicants for membership or applicants for change of previous grades have been admitted since the publication of the list in the last issue of the REVIEW.

Elected to Associate Fellow Grade

Brun, Edmon A., Dr. of Sc., Prof. of Fluid Mechanics, Sorbonne, Faculté des Sciences; Dir. of Heat Transfer Lab., French Natl. Center for Scientific Research; Div. Chief, Center of Research on Missiles.

Callahan, John G. P., A.E., Lt. Col., USAF; USAF Exchange Officer, Deputy Asst. Dir. of Instrument Research & Devel., Ministry of Supply (England).

Hall, S. Scott, C.B., FRAeS, Head, Research & Devel. Staff, British Joint Services Mission (Washington, D.C.).

Phillips, James F., B.S. in C.E., Maj. Gen. (Ret.), USAF; Staff Asst., Tech. Services, Aircraft Industries Association of America, Inc.

Sebold, Raymond C., B.S.M.E., Vice-President—Engrg., Consolidated Vultee Aircraft Corp.

Snyder, George, B.S.A.E., Chief, Prelim. Design, Boeing Airplane Co. (Seattle).

Transferred to Associate Fellow Grade

Bird, John D., B. of Ae.E. & B.S. in M.E., Aero. Research Scientist, N.A.C.A., Langley Field.

Farrar, Earl V., M.E., Asst. Chief Engr., Curtiss-Wright Corp.

Kelsey, Benjamin S., M.Ae.E., Brig. Gen., USAF; Deputy Dir. of Research & Devel., Hqs., Washington, D.C.

Pendley, Robert E., B.S. in Ae.E., Aero. Research Scientist, NACA, Langley Field.

Perkins, Courtland D., M.S. in Ae.E., Prof. & Chairman, Aero. Engrg. Dept., Princeton Univ.; Member, Subcommittee on Stability & Control, NACA; Aero. Cons., Chase Aircraft Co.; Cons., Adv. Group, AGARD (Paris); Cons., Weapons System Evaluation Group, Joint Chiefs of Staff.

Ryan, John H., B.M.E., Proj. Engr., Douglas Aircraft Co., Inc.

Speas, R. Dixon, Aviation Cons.

Elected to MEMBER Grade

Acker, Alden E., S.B., Vice-President & Dir., Hycon Mfg. Co.

Armstrong, Homer T., B.S. in M.E., Design Engr., Chance Vought Aircraft Div., United Aircraft Corp. (Dallas).

Barndollar, Ellen Jane, M.A., Research Engr., Douglas Aircraft Co., Inc. (Santa Monica).

Bateman, Robert E., B.S.A.E., Aerodynamics Engr., Boeing Airplane Co. (Seattle).

Beck, Niels J., Ph.D., Research Engr., Power Plant Analysis Group, Douglas Aircraft Co., Inc. (Santa Monica).

Benedict, Donald L., Ph.D. in Physics, Assoc. Chairman, Engrg. Research Div., Stanford Research Institute.

Cels, Andrew M., Ing. Civ. Mecanicen, Chief Engr., Société Anonyme Belge de Construction Aéronautiques.

Critoph, Richard J., Design Engr., Bell Aircraft Corp.

Crockett, G. St. Quintin, Deputy Wind Tunnel Mgr., Vickers-Armstrongs, Ltd.

Darracott, George F., B.S. in M.E., Proj. Engr., Chance Vought Aircraft Div., United Aircraft Corp. (Dallas).

Davie, Robert P., Jr., B.S., Group Leader, Wind Tunnel Model Group, North American Aviation, Inc.

Edse, Rudolph, Ph.D., Asst. Prof. & Research Supvr., Dept. of Aero. Engrg., The Ohio State Univ.

Ellis, Allen R., B.S.E.E., Group Head, Antenna Devel. Group, Stanford Research Institute.

Fulton, Robert E., Jr., B.S., President & Chief Engr., Continental, Inc.

Gobble, Wallace W., B.S. in M.E., Struct. Engr., Fletcher Aviation Corp.

Granger, Frank M., M.S.Ae.E., Prof. of Aero. Engrg., College of Engrg., Wayne Univ.

Green, Charles F., Ph.D., Cons. Engr., Aeronautic & Ordnance Systems Div., General Electric Co.

Herrmann, George, Dr. of Tech. Sc., Asst. Prof. of Civil Engrg., Columbia Univ., Cons., Swiss Association of Steel (Construction Firms).

Higginbottom, Samuel L., B.S. in C.E., Mgr. of Airframe Engrg., Trans World Airlines, Inc.

Howard, Darnley M., B.S. in M.E., Mech. Engr., Natl. Bureau of Standards (Washington, D.C.).

Kunznick, Gene A., B.S.A.E., Chief Weight Engr., McDonnell Aircraft Corp.

McCormack, Whitney, B.S., Asst. to Proj. Engr., Chance Vought Aircraft Div., United Aircraft Corp. (Dallas).

McDonnell, Sanford N., B.S.M.E., Design Engr., McDonnell Aircraft Corp.

Oliver, Thomas K., Sc.B., Major, USAF; Asst. Prof., USAF Institute of Tech., Wright-Patterson AFB.

Palme, H. O., C.E., Chief Aerodynamicist, SAAB Aircraft Co.

Schwartzberg, Milton A., M. of Ae.E., Sr. Aerodynamicist, The Glenn L. Martin Co.

Slagg, William R., Designer "A," Engr., Northrop Aircraft, Inc.

Stephenson, John Mitchell, B.Sc., Research Assoc., Div. of Engrg., Brown Univ.

Stone, John H., Engrg. Designer "B," Boeing Aiplane Co.

Van Ornum, David M., Col., USAFR; Tech. Specialist, Aerojet-General Corp.

Wan, Conrad C., Ph.D., Design Proj. Engr., Chance Vought Aircraft Div., United Aircraft Corp.

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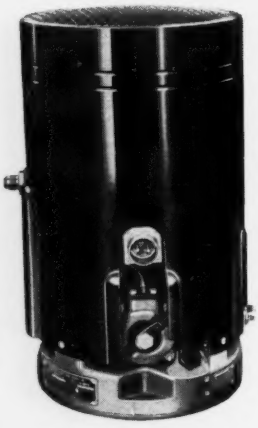

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Anderson, Gordon F., M.Sc., Research Assoc., Brown Univ.

Boyles, Richard Q., B. of Ae.E., Design Engr. "B," Lockheed Aircraft Corp.

Charwat, Andrew F., Ph.D. in M.E., Aerodynamicist, Propulsion Research Corp.

Cobb, James O., A.E., Col., USAF; Asst. Chief, Aircraft Lab., WADC, Wright-Patterson AFB.

Coddou, Joseph W., B.S.Ae.E., Design Engr., Wing & Tail Group, Consolidated Vultee Aircraft Corp. (San Diego).

Eatock, Henry C., B.A.Sc., Section Engr., Exp. Aerodynamics, Gas Turbine Engrg. Div., A. V. Roe Canada, Ltd.

Eggleston, John M., B.S. in Ae.E., Theoretical Stability & Control, Research Scientist, Flight Research Div., NACA, Langley Field.

Flickinger, Samuel J., Jr., M. of Ae.E., Aero. Research, Devel., & Design Engr., U.S.N., David Taylor Model Basin (Washington, D.C.).

Gething, Dorothy E., B.S., Tech. Member, Jr. Engr.—Aerodynamics, Boeing Airplane Co. (Seattle).

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Hazen, David C., M.S., Asst. Prof., Principal Investigator, B.L.C. Program with O.N.R.; Dir. of Subsonic Wind Tunnel Group, Princeton Univ.

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Lecat, Robert J., M.Ae.E., Aerodynamicist, Vitro Corp. of America.

Liner, George, B.Sc., Aero. Research Scientist, NACA, Langley Aero. Lab.

McCloud, John L., III, M.Sc. in Ae.E., Aero. Research Scientist, Ames Aero. Lab., NACA.

Michael, William H., Jr., M.S. in Ae.E., Aero. Research Scientist, Supersonic Aerodynamics Section, Gas Dynamics Branch, NACA, Langley Field.

Quan, Dick, M.S. in M.E., Design Engr., Gas Turbine Div., A. V. Roe Canada, Ltd.

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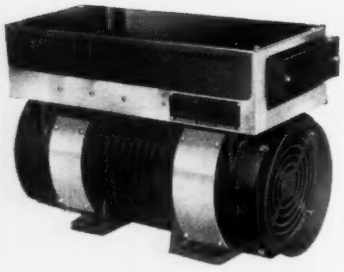

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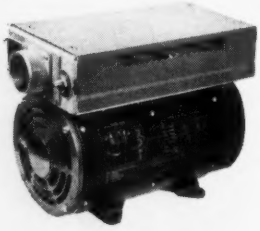

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Volts	115±4%
Amperes	21.7
Volt-Amperes	2500
Frequency-cps	400±10
Power Factor	.9 lag to .95 lead
Efficiency	55%
200% load	5 sec.
150% load	5 min.

WEIGHT: Approximately 62 pounds.

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Current Range	24.1 to 21.6
Current at 27.5 volts	22.8
Output AC	**Three Phase**
Volts	115/200±4% (115±4%, single phase)
Amperes	1.25/.723 (2.17, single phase)
Volt-Amperes	250 (single phase, three phase, or single and three phase combined)
Frequency-cycles/sec.	400±10
Power Factor	0.8 lag to .95 lead
Watts at 0.8 PF lag	200
Efficiency	40%
200% load	5 sec.
150% load	5 min.

WEIGHT: Approximately 17 pounds.

MAXIMUM OVER-ALL DIMENSIONS: 5½" wide x 8" high x 12" long.

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Walsh, Joseph G., B.A.E., Aerodynamicist, Engrg. Flight Test Sect., Grumman Aircraft Engrg. Corp.

Wenzel, James G., M.S. in Ae.E., Aerodynamics Engr., Consolidated Vultee Aircraft Corp.

Elected to Associate Member Grade

Bowater, John C., Aviation Claims & Tech. Supvr., Royal-Liverpool Insurance Group.

Collins, Kenneth A., Contract Rep., Aircraft Div., R & D Labs., Rheem Mfg. Co.

Dougherty, Frazer L. W., Vice-President—Sales, U.S. Propellers, Inc.

Gillmor, David E., Sales Mgr., Gillmors, Inc.

McGregor, Arch D., Capt. & Pilot, California Central Airlines.

Perry, Armand F., Flight Inspector, Grumman Aircraft Engineering Corp.

Rosenberg, Arnold, Asst. Vice-President, Operations, Kearfott Co., Inc.

Rosengren, Ernest G., Sr. Patent Draftsman & Designer, Sikorsky Aircraft Div., United Aircraft Corp.

Sellers, John H., Tech. Supvr., Aviation Dept., Insurance Co. of North America Companies.

Shaffer, William M., B.S. in Science & Education, Jr. Engr. "B," Service Engrg. Dept., Boeing Airplane Co. (Wichita).

Sherman, Lynn E., Head, Engrg. Contracts Sect., Aircraft Div., Globe Corp.

Wright, Jack P., B.S., Asst. Gen. Mgr., Aero Engineering, Inc.

Transferred to Associate Member Grade

Mazzio, Joann, B.S.Ae., Document Librarian & Asst. to Chief, Library, Air Force Special Weapons Center, Kirtland AFB (New Mexico).

White, James H., Maj., USAF; Chief, Quality Control Branch, Tokyo Procurement Field Office, Far East Air Logistic Force (Japan).

Elected to Technical Member Grade

Asher, Andrew J., M.S., Tech. Engr., General Electric Co. (Ohio).

Bresin, Sheldon O., B.S. in Ae.E., Design Engr., Temco Aircraft Corp.

Burns, Albert B., B.C.E., Struct. Devel. Engr., Chance Vought Aircraft Div., United Aircraft Corp. (Dallas).

Grisham, Norman D., Chief Liaison Engr., Temco Aircraft Corp.

Jensen, Soren C., Jr., B.S. in Ae.E., Aerodynamicist "B," Temco Aircraft Corp. (Dallas).

Jones, Claude D., Jr. Engr.—Stress, Lockheed Aircraft Corp.

Peters, Harold J., B.Sc. in Ed., Design Engr., North American Aviation, Inc.

Peterson, John J., Struct. Design Engr., Chance Vought Aircraft Div., United Aircraft Corp. (Dallas).

Smith, Edward E., Jr., B.S. in Air Transportation, Exp. Test Engr., Aero. Div., Curtiss-Wright Corp.

Stiles, Marvin E., B.S. in C.E., Struct. Engr., Chance Vought Aircraft Div., United Aircraft Corp. (Dallas).

Styerwalt, Alfred J., B.S. in M.E., Jr. Engr.-Draftsman "A," Lockheed Aircraft Corp.

Turetzky, Arthur A., B.S.M.E., Instructor (Nights), Illinois Institute of Tech.; Mech. Engr., Cook Research Labs.

Transferred to Technical Member Grade

Anderson, Richard W., B.S. in Ae.E., Jr. Engr.-Draftsman "B," North American Aviation, Inc. (Columbus).

Baciak, Albert M., B.S. in Ae.E., Flight Test Analysis Engr., Boeing Airplane Co. (Wichita).

Basile, John P., B.S. in Ae.E., Aerodynamicist—Devel. & Research, Chance Vought Aircraft Div., United Aircraft Corp.

Bell, Emily A., B.S., Jr. Engr.-Stress Analyst, Douglas Aircraft Co., Inc. (Long Beach).

Biering, Albert H., B.S. in Ae.E., Capt., USAFR; Aerodynamicist Engr., The Glenn L. Martin Co.; Guided Missile Field Test Div., NAMTC (Pt. Mugu).

Birk, William M., B.S. (Aero.), Jr. Engr., Chance Vought Aircraft Div., United Aircraft Corp.

Blottner, Frederick G., B.S., Grad. Student, Applied Mechanics, Virginia Polytechnic Institute.

Boskovich, Boris, B.S. & B. of Ae.E., Aerodynamicist, McDonnell Aircraft Corp.

Brenner, George P., Maj. & Sr. Pilot, USAF; Chief, Engrg. Services Branch, Eglin AFB.

Brown, Forrest H., B.S.

Chinoy, Rustam B., B.Sc., Mech. & Elec. Engrg., Design Engr. "B," Engrg. Dept., Republic Aviation Corp.

Clark, Howard G., B.S. in Ae.E., Aero. Engr., GS-5, Component Test Dept., Airframes Div., NAMTC (Pt. Mugu).

Dyas, David D., B.S., Maj. & Sr. Pilot, USAF; Proj. Engr., ADC, Wright-Patterson AFB.

Eagle, Howard A., Jr., A.E., Assoc. Engr., Stress Group, Douglas Aircraft Co., Inc. (Santa Monica).

Fastiggi, James J., B.S. in Ae.E., Engrg. Draftsman "B," North American Aviation, Inc. (Los Angeles).

Grudberg, Henry B., A.E., Asst. Proj. Engr., Burton-Rodgers, Inc.

Hadden, Robert B., B.S. in Ae.E., Lt., U.S.N.; Grad. Student, Massachusetts Institute of Technology.

Hamilton, Leonard A., B.S., Lt., USAF; Proj. Engr., Rocket Power Plant Devel., WADC, Wright-Patterson AFB.

Harrison, Robert C., B.E., Maj., USAF; Chief, Elec. Branch, Airborne Equip. Div., Directorate of Equip., Hq., ARDC (Baltimore).

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Discovery of a better way to house radar is further proof of Douglas leadership in aviation. Light, tough Radome expresses a basic Douglas philosophy—*farther and faster with a bigger payload.*

Enlist to fly in the U. S. Air Force

Depend on *DOUGLAS* **First in Aviation**

Aeronautical Reviews

A Guide to the Current Literature of Aeronautical Research and Engineering

I. PERIODICALS AND REPORTS

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Bibliographies on special subjects will be compiled at the rate of $2.50 per hour. *Translations* of technical literature from foreign languages may be obtained at $12 to $14 per 1,000 words, depending on the language. IAS members receive a 20 per cent discount on bibliographies and translations.

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Abbreviations for Titles of Periodicals and Reports

Titles of periodicals and reports cited in the Aeronautical Reviews Section are abbreviated in order to conserve space and to expedite the flow of materials. Selection of titles in this list of abbreviations is based on materials received during the past year. Reference citations are listed in the briefest form, with only the first page given for periodicals and the total number of pages for reports and other types of publications.

Publications reviewed are filed permanently in the IAS Library. Requests for loans of materials should be directed to the Librarian, IAS Library, 2 E. 64th St., New York 21, N.Y.

A&M Coll. Tex. Eng. Exp. Sta. Res. Rep. Agricultural and Mechanical College of Texas, Texas Engineering Experiment Station, Research Report

Acta Polytechnica (Stockholm)

Aero Dig. Aero Digest

Aero. Eng. Rev. Aeronautical Engineering Review

Aero. Quart. The Aeronautical Quarterly

Aero Res. TN; Bul. Aero Research Technical Notes; Bulletin

Aerodynamisches Inst. Tech. Hochschule, Braunschweig, Bericht. Aerodynamisches Institut der Technischen Hochschule, Braunschweig, Bericht

Aeronautics

The Aeroplane

L'Aerotecnica (Rome)

Aerovox Res. Worker. Aerovox Research Worker

AHS Papers. American Helicopter Society, Papers

AIAA Papers. Aircraft Industries Association of America, Papers

AIEE Papers. American Institute of Electrical Engineers, Papers

Air Facts

Air Force

Air Line Pilot

Air Pictorial

Air Transp. Air Transportation

Air U. Quart. Rev. Air University Quarterly Review

Airborne Instr. Lab. Proj. Rep. Airborne Instruments Laboratory, Project Report

Aircraft (Australia)

Aircraft (Canada)

Aircraft Eng. Aircraft Engineering

Aircraft Heating Dig. Aircraft Heating Digest

Aircraft Prod. Aircraft Production

Airport Operators Council, Papers

Airports & Air Transp. Airports & Air Transportation

Allis-Chalmers Elec. Rev. Allis-Chalmers Electrical Review

ALPA Papers. Air Line Pilots Association, Papers

Am. Av. American Aviation

Am. Helicopter. American Helicopter

Am. J. of Phys. American Journal of Physics

Anal. Chem. Analytical Chemistry

Antiaircraft J. Antiaircraft Journal

Appl. Hydraulics. Applied Hydraulics

Appl. Mech. Rev. Applied Mechanics Reviews

Appl. Sci. Res., Sect. A. Applied Scientific Research, Section A (Mechanics, Heat, Chemical Engineering, Mathematical Methods)

Appl. Sci. Res., Sect. B. Applied Scientific Research, Section B (Electrophysics, Acoustics, Optics, Mathematical Methods)

Argonne Natl. Lab. Rep. Argonne National Laboratory, Reports

ASCE Air Transp. Div. Papers; Preprints. American Society of Civil Engineers, Air Transport Division, Papers; Preprints

ASME Preprints; Papers. American Society of Mechanical Engineers, Preprints; Papers

ASTM Bul. American Society for Testing Materials, Bulletin

ATA Papers. Air Transport Association (of America), Papers

Audio Eng. Audio Engineering

Australia, Aero. Res. Consultative Comm. Rep. Australia, Department of Supply, Aeronautical Research Consultative Committee, Reports

Australia, ARL EN; IN; Rep.; S&M Monogr.; S&M TM; Notes. Australia, Department of Supply, Aeronautical Research Laboratories, Engines Note; Instruments Note; Reports; Structures and Materials Monographs; Structures and Materials Technical Memorandum; other Notes

Australian J. of Appl. Sci. Australian Journal of Applied Science

Australian J. Phys. Australian Journal of Physics [formerly Australian Journal of Scientific Research, Series A (Physical Sciences)]

Auto. Ind. Automotive Industries

Av. Age. Aviation Age

Av. Week. Aviation Week

Bearing Engr. Bearing Engineer

Bee Hive

Bell Aircraft Rep. Bell Aircraft Corporation, Reports

Bell System Tech. J. Bell System Technical Journal

Bendix Av. Eng. Rep. Bendix Aviation Corporation, Engineering Reports

Boeing Mag. Boeing Magazine

Brit. Aircraft Ind. Bul. British Aircraft Industry Bulletin

Brit. J. Appl. Phys. British Journal of Applied Physics

Brown-Boveri Rev. Brown-Boveri Review

Bul. AMS. Bulletin of the American Meteorological Society

Bus. Flying. Business Flying

Canada, NAE LR; Note; Quart. Bul.; Rep. Canada, National Aeronautical Establishment, Laboratory Report; Note; Quarterly Bulletin; Report.

Canada, NRC Div. Mech. Eng. Rep. Canada, National Research Council, Division of Mechanical Engineering, Reports

Canada, RCAF, Rockcliffe, Rep. Canada, Royal Canadian Air Force, Rockcliffe, Report

Can. Airline Pilot. Canadian Airline Pilot

Can. Av. Canadian Aviation

Can. J. Phys. Canadian Journal of Physics

Can. J. Tech. Canadian Journal of Technology

CEC Recordings

Chrysler Eng. Div. Rep. Chrysler Corporation, Engineering Division, Reports

CIT Jet Propulsion Lab. Prog. Rep. California Institute of Technology, Jet Propulsion Laboratory, Progress Reports

CIT Mech. Eng. Lab. Rep. California Institute of Technology, Mechanical Engineering Laboratory, Reports

CIT Papers. California Institute of Technology, Papers

Coll. of Aeronautics, Cranfield, Rep. College of Aeronautics, Cranfield, England, Reports

Collins Signal

Commun. on Pure & Appl. Math. Communications on Pure and Applied Mathematics

Cook Res. Labs. Papers. Cook Research Laboratories, Papers

Cornell Aero. Lab. FRM; Rep.; Transl. Cornell Aeronautical Laboratory, Inc., Flight Research Memorandum; Reports; Translations

Cornell U. Med. Coll. Crash Injury Res. Papers. Cornell University Medical College, Crash Injury Research Papers

Corrosion

Curtiss-Wright Corp., Wright Aero. Div., Rep. Curtiss-Wright Corporation, Wright Aeronautical Division, Reports

de Havilland Gazette

Dickinson Law Rev. Dickinson Law Review

Douglas Rep. Douglas Aircraft Company, Inc., Reports

Douglas Serv. Douglas Service

Elec. Commun. Electrical Communication

Elec. Eng. Electrical Engineering

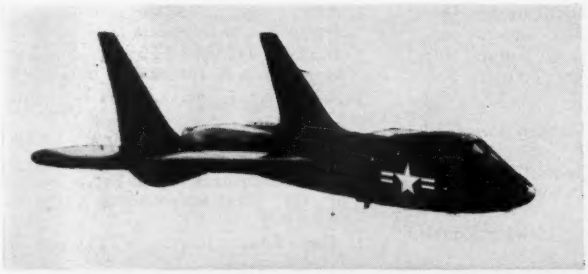
Elec. Mfg. Electrical Manufacturing

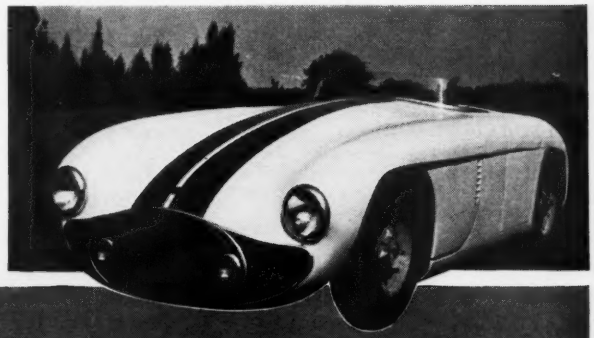
Electronic Eng. Electronic Engineering

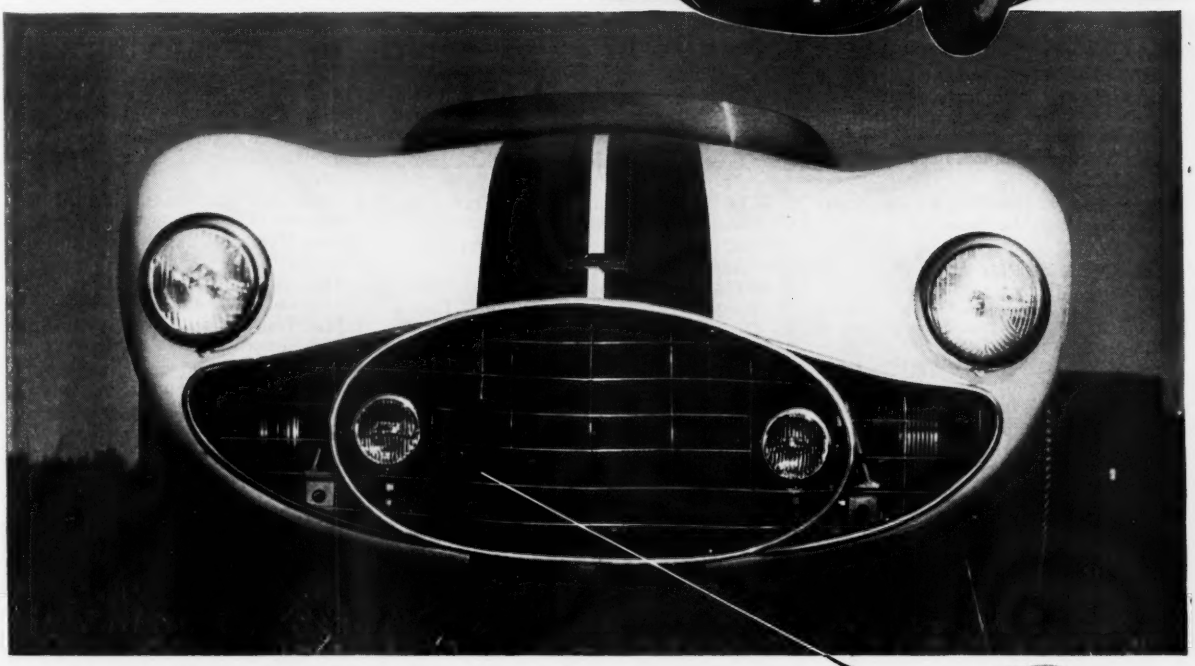
Electronics

Electronics Forum. See: Proc. Inst. Electronics

Eng. J. Engineering Journal







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The Engr. The Engineer

Engr. Dig. Engineer's Digest

Escher Wyss News

Esso Air World

Esso Standard Oil Co. Rep. Esso Standard Oil Company Reports

ETH Inst. für Aerodynamik (Zurich), Mitteilungen. Eidgenössische Technische Hochschule, Institut für Aerodynamik (Zurich), Mitteilungen

Fasteners

Flight

Flight Control (Bendix)

Flight Mag. Flight Magazine

Flight Safety Foundation Mech. Bul. Flight Safety Foundation, Inc., Mechanics Bulletin

Flight Safety Foundation, Papers

Flying

Flying Safety (USAF). Flying Safety (United States Air Force)

Foote Prints

France, Min. de l'Air BST; NT; PST. France, Ministère de l'Air, Bulletin des Services Techniques; Notes Techniques; Publications Scientifiques et Techniques

France, ONERA Pubs. France, Office National d'Études et de Recherches Aéronautiques, Publications

Franklin Inst. Labs. TR. Franklin Institute Laboratories for Research and Development, Technical Reports

The Frontier

Fulmer Res. Inst. Rep. Fulmer Research Institute Limited, Reports

GALCIT Memo. Guggenheim Aeronautical Laboratory, California Institute of Technology, Pasadena, Calif., Memorandums

Garbell Res. Foundation, Aero. Ser. Garbell Research Foundation, Aeronautical Series

G-E Rev. General Electric Review

Gen. Radio Exp. General Radio Experimenter

GM Eng. J. General Motors Engineering Journal

Gt. Brit., AAEE Rep. Great Britain, Aeroplane and Armament Experimental Establishment, Boscombe Down, Reports

Gt. Brit., AERE Rep. Great Britain, Atomic Energy Research Establishment, Reports

Gt. Brit., ARC CP. Great Britain, Aeronautical Research Council, Current Papers

Gt. Brit., ARC R&M. Great Britain, Aeronautical Research Council, Reports & Memoranda

Gt. Brit., Meteorological Off. Prof. Notes & Reps. Great Britain, Meteorological Office, Professional Notes and Reports

Gt. Brit., MOS DGC TIB Rep. & Transl. Great Britain, Ministry of Supply, Government Defense Council, Technical Information Bureau, Reports and Translations

Gt. Brit., NGTE Rep. Great Britain, National Gas Turbine Establishment, Reports

Gt. Brit., NPL Aerodynamics Div. Rep. Great Britain, National Physical Laboratory, Aerodynamics Division, Reports

Gt. Brit., RAE Rep. Great Britain, Royal Aircraft Establishment, Reports

Gt. Brit., RAE TN. Great Britain, Royal Aircraft Establishment, Technical Notes

Handley-Page Bul. Handley-Page Bulletin

Harvard U. Cruft Lab. TR. Harvard University, Cruft Laboratory, Technical Reports

Hawker Siddeley Rev. Hawker Siddeley Review

Hewlett-Packard J. Hewlett-Packard Journal

Hunting Group Rev. Hunting Group Review

Hydraulic Engr. Hydraulic Engineer

AS Preprints; Papers. Institute of the Aeronautical Sciences, Preprints; Papers

IATA Bul. International Air Transport Association Bulletin

ICAO Bul. International Civil Aviation Organization Bulletin

IME Auto. Div. Proc. Institution of Mechanical Engineers, Automobile Division, Proceedings

IME Proc. (A). Institution of Mechanical Engineers, Proceedings (A)

IME Proc. (B), Appl. Mech.; Hydraulics Institution of Mechanical Engineers Proceedings (B), Applied Mechanics Hydraulics

INCO. (International Nickel Company, Inc.)

Ind. & Eng. Chem. Industrial and Engineering Chemistry

Ind. Quality Control. Industrial Quality Control

Indian AF Quart. Indian Air Force Quarterly

Indian Airman

Indian Skyways

Institut Français du Transport Aérien, Res. Papers. Institut Français du Transport Aérien, Research Papers

Instrumentation

Instruments

Interavia (Monthly)

Interchem. Rev. Interchemical Review

Internatl. Nickel Devel. & Res. Div. Tech. Bul. International Nickel Company, Development & Research Division, Technical Bulletins

Ireland, Meteorological Serv., Geophys. Pubs. Ireland, Meteorological Service, Geophysical Publications

ISA J. Instrument Society of America Journal. In: **Instruments**

Istanbul Tech. U. Bul. Instanbul Technical University, Bulletin

J. Acoustical Soc. Am. Journal of the Acoustical Society of America

J. ACS. Journal of the American Chemical Society

J. Aero. Sci. Journal of the Aeronautical Sciences

J. Aero. Soc. India. Journal of The Aeronautical Society of India

J. Air Law & Commerce. Journal of Air Law & Commerce

J. Appl. Mech. Journal of Applied Mechanics

J. Appl. Phys. Journal of Applied Physics

J. ARS. Journal of the American Rocket Society. See **Jet Propulsion**

J. ASNE. Journal of the American Society of Naval Engineers

J. Atmos. & Terrestrial Phys. Journal of Atmospheric & Terrestrial Physics

J. Av. Med. Journal of Aviation Medicine

J. Brit. Interplanetary Soc. Journal of the British Interplanetary Society

J. Electrodepositors' Tech. Soc. Journal of the Electrodepositors' Technical Society

J. Eng. Educ. Journal of Engineering Education

J. Exp. Biol. The Journal of Experimental Biology

J. Franklin Inst. Journal of the Franklin Institute

J. GAPAN. Journal of the Guild of Air Pilots and Air Navigators

J. Helicopter Assn. Gt. Brit. Journal of the Helicopter Association of Great Britain

J. Indian Inst. Sci. Journal of the Indian Institute of Science

J. Inst. Metals. Journal of the Institute of Metals

J. Inst. Navigation. Journal of the Institute of Navigation

J. Inst. Transp. Journal of the Institute of Transport

J. Japan Soc. Appl. Mech. Journal of the Japan Society for Applied Mechanics

J. London Math. Soc. Journal of the London Mathematical Society

J. Math. & Phys. Journal of Mathematics and Physics

J. Mech. & Phys. Solids. Journal of the Mechanics and Physics of Solids

J. Meteorology. Journal of Meteorology

J. RAeS. Journal of the Royal Aeronautical Society

J. Sci. & Ind. Res. Journal of Scientific and Industrial Research

J. Sci. Instr. Journal of Scientific Instruments

J. Sci. Res. Journal for Scientific Research

J. SCMA. Journal of the Southern California Meter Association. In: **Instruments**

J. SLAE Journal of the Society of Licensed Aircraft Engineers (incorporating The Technical Instructor)

J. Southern Res. Journal of Southern Research

J. Space Flight. Journal of Space Flight

Japan, NCB Rep. Japan, Numerical Computation Bureau, Reports

Japan Sci. Rev. Japan Science Review (Engineering Sciences)

Jet Age

Jet Propulsion. (Formerly, J. ARS.)

Kyushu U., Japan, Res. Inst. Appl. Mech. Rep. Kyushu University, Japan, Research Institute for Applied Mechanics, Reports

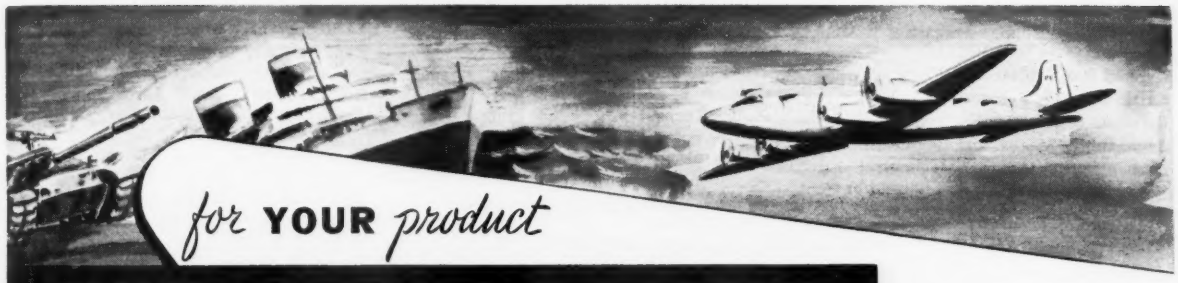
La. State U. Eng. Exp. Sta. Bul. Louisiana State University, Engineering Experiment Station, Bulletin

Lenkurt Demodulator

Lockheed Aircraft Rep. Lockheed Aircraft Corporation, Reports

The Log

Lubrication



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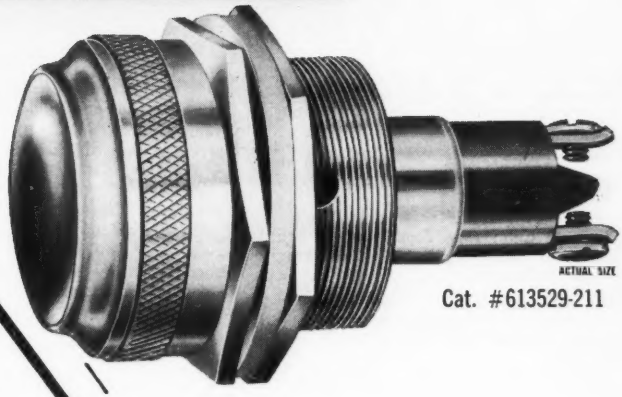

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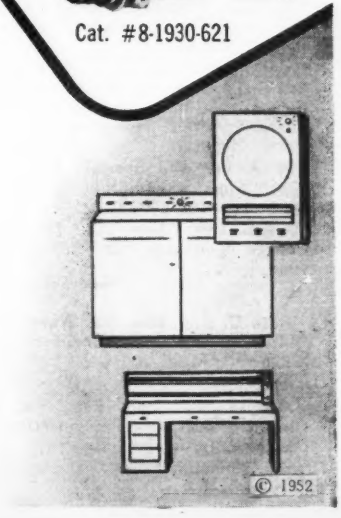

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Mach. Des. Machine Design
Mag. of Magnesium. Magazine of Magnesium
Marconi Rev. Marconi Review
Martin Star
Materials & Methods
Mech. Eng. Mechanical Engineering
Mech. Engr. (India). Mechanical Engineer, Bangalore, India (Journal of the Mechanical Engineering Society, Indian Institute of Science)
Metal Treatment
Metallurgia
Meteorological Mag. The Meteorological Magazine
Mil. Surgeon. Military Surgeon
Miss. State U. Eng. Res. Sta. Res. Rep. Mississippi State University, Engineering Research Station, Research Reports
Mitteil. Hydraulischen Inst. Tech. Hochschule, München. Mitteilungen des Hydraulischen Instituts der Technischen Hochschule, München
Mitteil. Max-Planck-Inst. für Strömungsforschung. Mitteilungen aus dem Max-Planck-Institut für Strömungsforschung (Göttingen)
Modern Metals
Motorola Newsgram

N.C. State Coll., Eng. Sch. Bul. North Carolina State College, Engineering School Bulletin
Natl. Acad. Sci., NRC Rep. National Academy of Sciences of the United States, National Research Council, Reports
Natl. Assn. State Av. Off. Papers. National Association of State Aviation Officials, Papers
NATO AGARD Memo. North Atlantic Treaty Organization, Advisory Group for Aeronautical Research and Development, Memorandum
Naval Av. News. Naval Aviation News
Navigation
Netherlands, Mathematisch Centrum, Amsterdam, Rep. (Reports)
Netherlands, NLL Rep. (Rep. & Trans.) Netherlands, Nationaal Luchtvaartlaboratorium (National Aeronautical Research Institute), Amsterdam, Reports (Reports and Transactions)
New Frontiers
New Zealand Flying
NFPA Bul.; Papers; Rep. National Fire Protection Association, Bulletins; Papers; Reports
NFPA Comm. Av. & Airport Fire Protection Bul.; Rep. National Fire Protection Association, Committee on Aviation and Airport Fire Protection, Bulletins; Reports
North Amer. Av. Special Res. Rep. North American Aviation Corporation, Special Research Reports
NYU Res. Rev. New York University, College of Engineering, Research Review

O. State U. Eng. Exp. Sta. News. The Ohio State University, Engineering Experiment Station, News
Ordnance
Ore. State Coll. Eng. Exp. Sta. Bul. Oregon State College, Engineering Experiment Station, Bulletin
Organic Finishing
The Oscillographer

Pacific J. Math. Pacific Journal of Mathematics
Papers in Meteorology & Geophys. Papers in Meteorology and Geophysics
Pegasus
Philips Tech. Rev. Philips Technical Review
Philos. Mag. Philosophical Magazine
Photogrammetria
Photogrammetric Eng. Photogrammetric Engineering
Photographic Eng. Photographic Engineering
Power Jets Memo. Power Jets (Research and Development) Limited, Memorandum
Princeton U. Aero. Eng. Lab. Rep. Princeton University, Aeronautical Engineering Laboratory, Reports
Proc. Cambridge Philos. Soc. Proceedings Cambridge Philosophical Society
Proc. IEE, Part I. Proceedings of the Institution of Electrical Engineers, Part I (General)
Proc. IEE, Part II. Proceedings of the Institution of Electrical Engineers, Part II (Power Engineering)
Proc. IEE, Part III. Proceedings of the Institution of Electrical Engineers, Part III (Radio and Communication Engineering)
Proc. Inst. Electronics. Proceedings of the Institution of Electronics (Electronics Forum)
Proc. IRE. Proceedings of the Institute of Radio Engineers
Proc. London Math Soc., 2nd Ser.; 3rd Ser. Proceedings of the London Mathematical Society, 2nd Series; 3rd Series
Proc. Phys. Soc., Sect. B. Proceedings of the Physical Society (British), Section B
Proc. Royal Netherlands Acad. Sci., Amsterdam, Ser. A; Ser. B; Ser. C Proceedings of the Royal Netherlands Academy of Sciences at Amsterdam, Series A (Mathematical Sciences); Series B (Physical Sciences, containing, e.g., Astronomy, Chemistry, Geology, Physics, Technical Sciences); Series C (Biological and Medical Sciences)
Proc. Royal Soc. (Edinburgh). Proceedings of the Royal Society (Edinburgh)
Proc. Royal Soc. (London), Ser. A. Proceedings of the Royal Society (London), Series A (Mathematical and Physical Sciences)
Prod. Eng. Product Engineering
Prof. Engr. Professional Engineer
Purdue U. TR. Purdue University, Technical Reports

Quadrangle
Quart. Appl. Math. Quarterly of Applied Mathematics
Quart. J. Mech. & Appl. Math. Quarterly Journal of Mechanics and Applied Mathematics
Quart. J. Royal Meteorological Soc. Quarterly Journal of the Royal Meteorological Society

Radio & TV News. Radio & Television News
Radio-Electronic Eng. Sect. Radio-Electronic Engineering Section, In: **Radio & TV News**
Radio Tech. Comm. Aeronautics, Papers. Radio Technical Commission for Aeronautics, Papers
RAND Corp. Transl. The RAND Corporation, Translations
RCA Rev. RCA Review
La Recherche Aéronautique (Paris)
Republic Av. Rep. Republic Aviation Corporation, Reports
Res. Trends (Cornell Aero. Lab.). Research Trends (Cornell Aeronautical Laboratory, Inc.)
Rev. Sci. Instr. Review of Scientific Instruments
Revista de Aeronáutica (Madrid)
Revista Nacional de Aeronautica (Buenos Aires)
Reynolds Metals Tech. Adviser. Reynolds Metals Technical Adviser
La Ricerca Sci. La Ricerca Scientifica (Rome)
Rivista Aeronautica (Rome)
Rockets
Rolls-Royce Bul. Rolls-Royce Bulletin
Ryan Reporter

Saab Sonics (Sweden)
Saab TN. Saab Technical Notes
SAE Aero. Info. Rep. Society of Automotive Engineers, Aeronautical Information Report
SAE J. SAE Journal
SAE Preprints; Papers. Society of Automotive Engineers, Preprints; Papers
Sailplane & Glider.
Saro Prog. Saro Progress
Särtryck ur Tellus
Science
Sheet Metal Ind. Sheet Metal Industries
Shell Av. News. Shell Aviation News
Skyline. (North American Aviation, Inc.)
Skyways
SNCASO Papers. Société Nationale de Constructions Aéronautiques du Sud-Ouest, Papers
Soaring
Solar Blast
SPE J. Society of Plastics Engineers, Journal
Sperry Gyroscope Rep. Sperry Gyroscope Company, Reports
Sperry Rev. Sperry Review
Sperryscope
Stanford Res. Inst. Res. Ind. Stanford Research Institute, Research for Industry
State Coll. Ia. Eng. Exp. Sta. TR. State College of Iowa, Engineering Experiment Station, Technical Reports
Steel Horizons
Steel Processing
Stockholm, KTH AERO TN. Stockholm, Kungliga Tekniske Högskola, Institutionen för Flygteknik, Technical Notes
Structural Engr. Assn. Calif. Rep. Structural Engineers Association of California, Reports
Sverdrup & Parcel Transl. Rep. Sverdrup & Parcel, Inc., Translation Reports
Sweden, Flygtekniska Försöksanstalten, FFA Meddelande
Syracuse U. Transp. Conf. Papers. Syracuse University, Transportation Conference, Papers

Taylor Tech. Taylor Technology
Tech. et Sci. Aéronautiques. Technique et Science Aéronautiques (Paris)
Tech. Rev. Technology Review
Tele-Tech
Tool Engr. Tool Engineer
Trans. AIEE. Transactions of the American Institute of Electrical Engineers

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OR
BAY SHORE 7-6500
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Trans. ASME. Transactions of the American Society of Mechanical Engineers

Trans. Inst. Welding. Transactions of the Institute of Welding

Trans. IRE Prof. Group on Microwave Theory & Techniques. Transactions of the Institute of Radio Engineers, Professional Group on Microwave Theory and Techniques

Trans. Soc. Inst. Tech. Transactions of the Society of Instrument Technology

Transp. & Commun. Rev. Transport and Communications Review

Transport (India)

Trend in Eng. The Trend in Engineering

U. Ark. Engr. Exp. Sta. Bul. University of Arkansas, Engineering Experiment Station, Bulletin

U. Calif. Pubs. in Eng. University of California, Publications in Engineering

U. Ill. Bul. University of Illinois, Bulletins

U. Ill. Eng. Exp. Sta. Bul.; TR. University of Illinois, Engineering Experiment Station, Bulletins; Technical Reports

U. Md. Inst. Fluid Dynamics & Appl. Math., Lecture Ser. University of Maryland, Institute for Fluid Dynamics and Applied Mathematics, Lecture Series

U. Mich. Eng. Res. Inst. Rep. University of Michigan, Engineering Research Institute, Reports

U. Minn. Inst. Tech. Dept. Aero. Eng., Res. Rep. University of Minnesota, Institute of Technology, Department of Aeronautical Engineering, Research Reports

U. Toronto Inst. Aerophys. Rev.; Rep. University of Toronto, Institute of Aerophysics, Review; Reports

U. Wash. Eng. Exp. Sta. Bul.; Reprints. University of Washington, Engineering Experiment Station, Bulletins; Reprints

U. Wis. NRL Dept. Chem. Rep. University of Wisconsin, Naval Research Laboratory, Department of Chemistry, Reports

United Air Lines News

U.S. AEC Rep. United States Atomic Energy Commission, Reports

U.S., Bur. Mines Bul.; Rep. Invest. United States, Bureau of Mines, Bulletin; Report of Investigations

U.S., CAA TDR. United States, Civil Aeronautics Administration, Technical Development Reports

U.S., Forest Prod. Lab. Rep. United States, Forest Products Laboratory, Madison, Wis., Reports

U.S., NACA Rep.; RM; TM; TN. United States, National Advisory Committee for Aeronautics, Report; Research Memorandum; Technical Memorandum; Technical Notes

U.S., NADC Rep. U.S., Naval Air Development Center, Reports

U.S., NAES Rep. United States, Naval Air Experiment Station, Reports

U.S., NAVORD Rep. United States, Naval Ordnance, Reports

U.S., Navy Dept. BuAer RDR. United States, Navy Department, Bureau of Aeronautics, Research Division Reports

U.S., Navy Dept., David W. Taylor Model Basin, Rep.; Transl. United States, Navy Department, David W. Taylor Model Basin, Reports; Translations

U.S., NBS J. Res. United States, National Bureau of Standards, Journal of Research

U.S., NBS Sum. TR. United States, National Bureau of Standards, Summary Technical Reports

U.S., NBS Tech. News Bul. United States, National Bureau of Standards, Technical News Bulletin

U.S., NRL Rep. United States, Naval Research Laboratory, Reports

U.S., ONR Res. Rep. United States, Office of Naval Research, Research Report (monthly)

U.S., ONR Special Devices Cen. TR. United States, Office of Naval Research, Special Devices Center, Technical Reports

U.S., Weather Bur. Mo. Weather Rev. United States, Weather Bureau, Monthly Weather Review

USAF AMC Eng. Div. Aero Med. Lab. TR. United States Air Force, Air Materiel Command, Engineering Division, Aero Medical Laboratory, Technical Reports

USAF APG Rep. United States Air Force, Air Proving Ground, Reports

USAF MATS Rep.; Papers. United States Air Force, Military Air Transport Service, Reports; Papers

USAF SAM Rep. United States Air Force, School of Aviation Medicine, Reports

USAF TR. United States Air Force, Technical Reports

U.S. Air Serv. U.S. Air Services

U.S. Armed Forces Med. J. United States Armed Forces Medical Journal

U.S. Naval Inst. Proc. United States Naval Institute, Proceedings

U.S. Steel Lubricants Testing Lab. Rep. United States Steel Lubricants Testing Laboratory, Reports

Va. J. Sci. The Virginia Journal of Science

VPI Eng. Exp. Sta. Ser. Bul. Virginia Polytechnic Institute, Engineering Experiment Station, Series Bulletin

W. U. Tech. Rev. Western Union Technical Review

Welding J. Welding Journal

Welding J. Res. Suppl. Welding Journal, Research Supplement

Welding Res. Welding Research (London)

Weltraumfahrt (Frankfurt am Main)

Western Av. Western Aviation

Westinghouse Engr. Westinghouse Engineer

Whites' Av. Whites' Aviation

Wireless Engr. Wireless Engineer

Wireless World

WMO Bul. World Meteorological Organization Bulletin

Z. VDI. Zeitschrift des Vereins Deutscher Ingenieure (Berlin)

ZAMM. Zeitschrift für angewandte Mathematik und Mechanik (Berlin)

ZAMP. Zeitschrift für angewandte Mathematik und Physik (Zurich)

ZFW. Zeitschrift für Flugwissenschaften (Braunschweig)

Zurich Tech. U. Papers. Zurich Technological University, Papers

ZWB UM. Zentrale für Wissenschaftliches Berichtswesen ueber Luftfahrtsforschung, Untersuchungen und Mitteilungen

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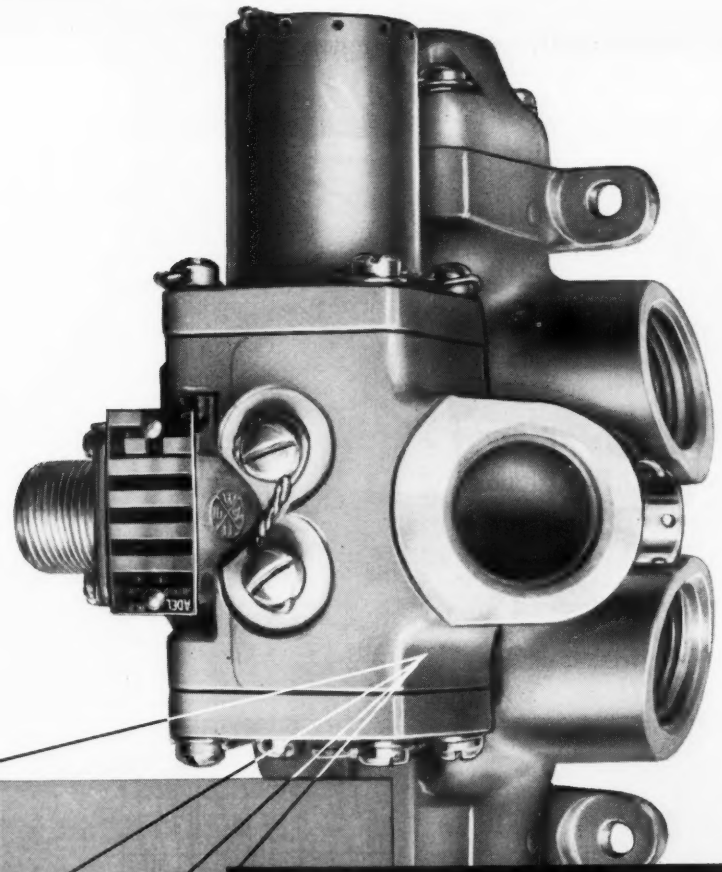

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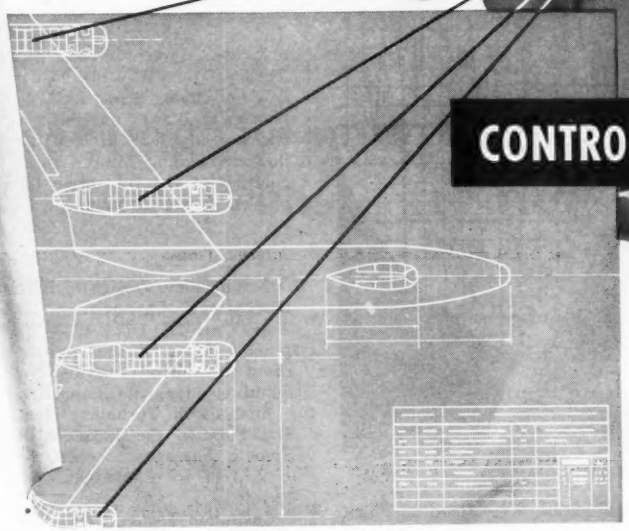

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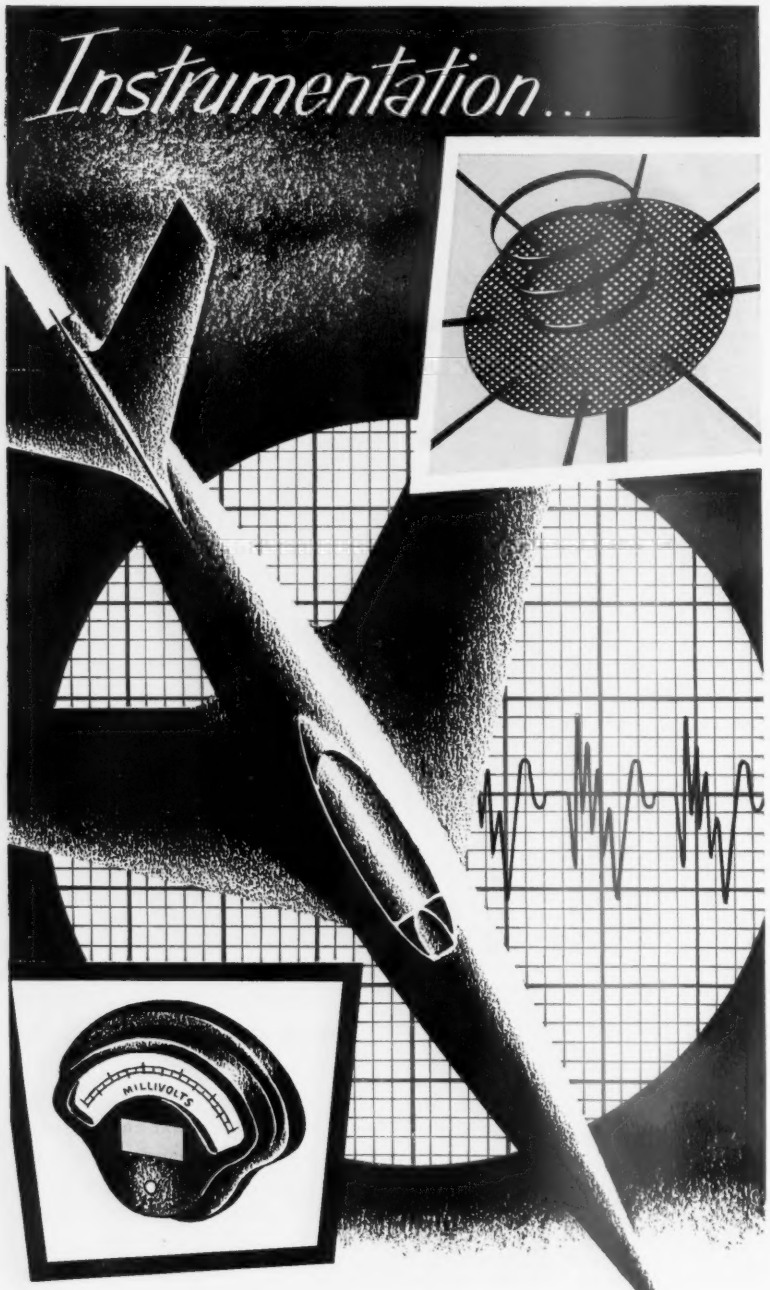

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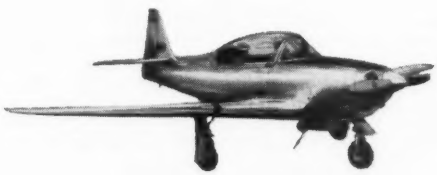

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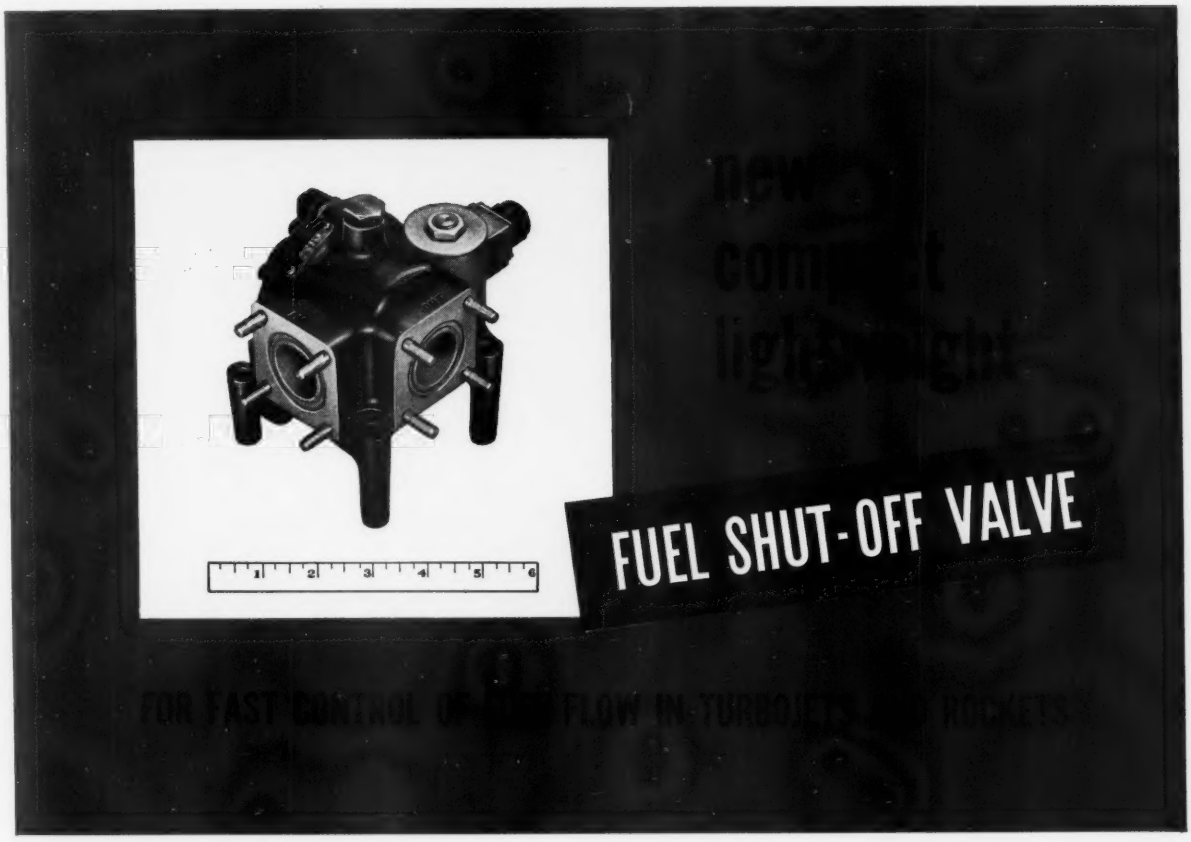

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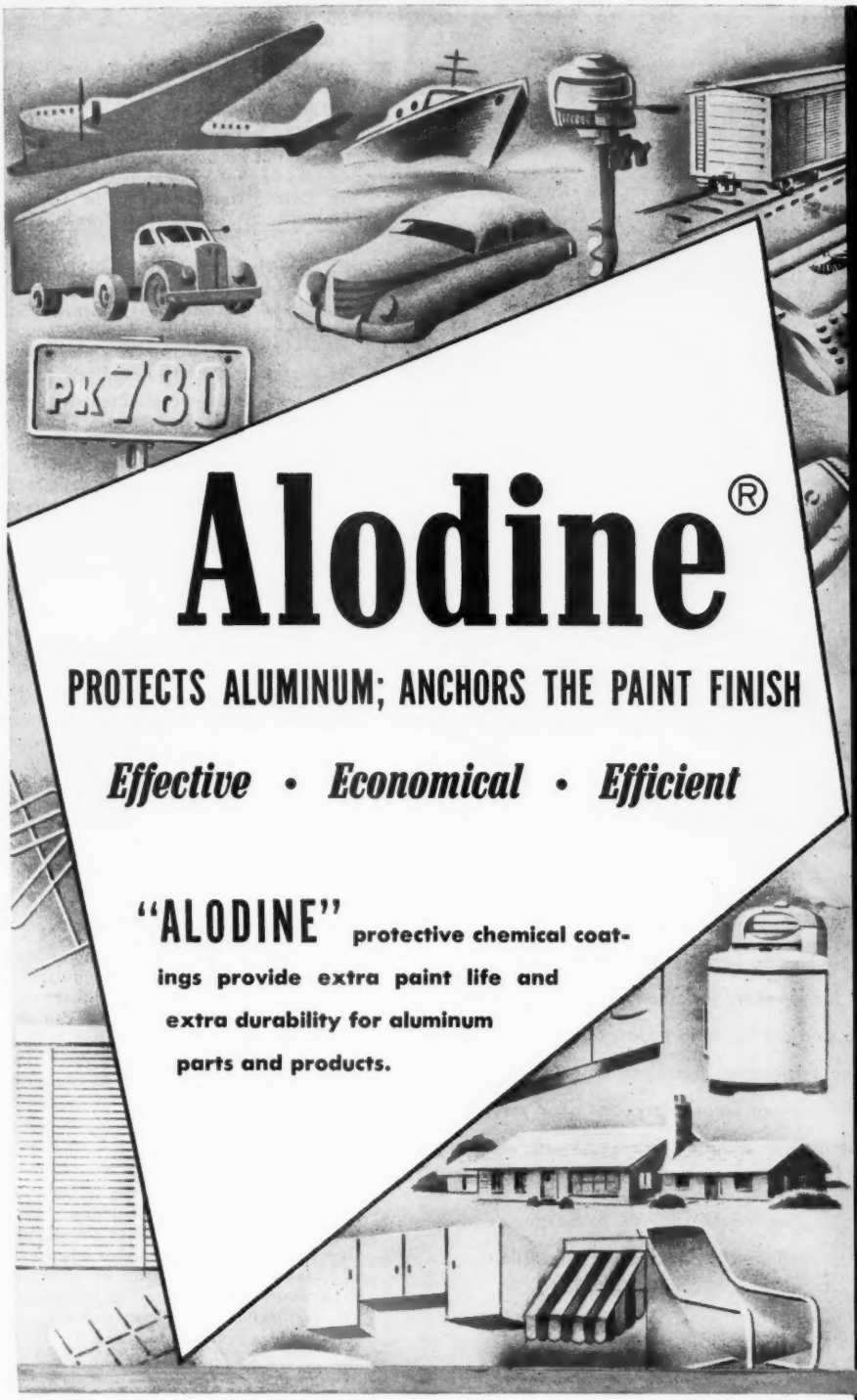

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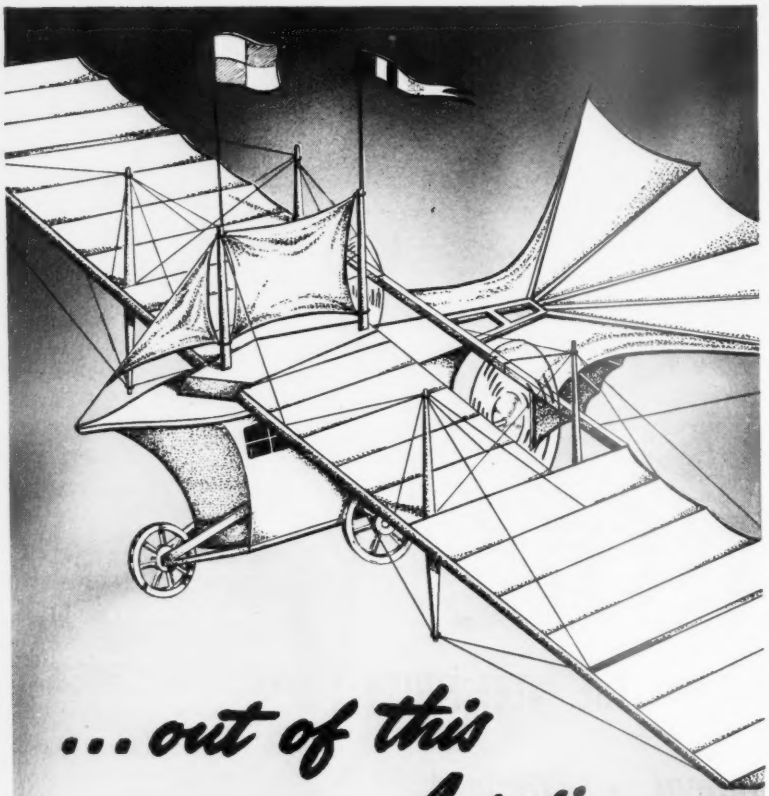

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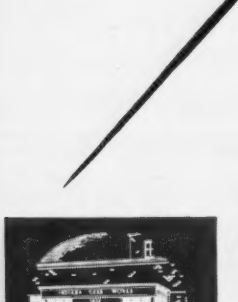

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Silicone News

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Typical Damping Applications For Silicone Fluid Simplify Design, Improve Performance

In designing the new Time-Master dictating machine, engineers at Dictaphone Corporation developed an ingenious device for damping the drop of the recording head onto the plastic Dictabelt recording medium. This device protects the diamond point on the recording stylus; prevents sharp indentation of the belt at the point of first contact; helps the recording head to ride smoothly over a slightly creased or damaged belt.

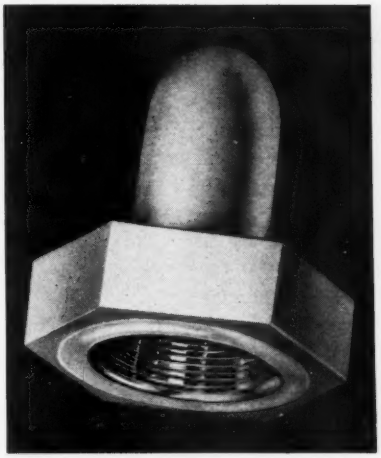
Dow Corning 200 Fluid was selected as the damping medium because its remarkably flat viscosity - temperature slope assures a constant damping force over the entire range of climatic temperatures. High resistance to oxidition and gumming assures long, trouble-free service.

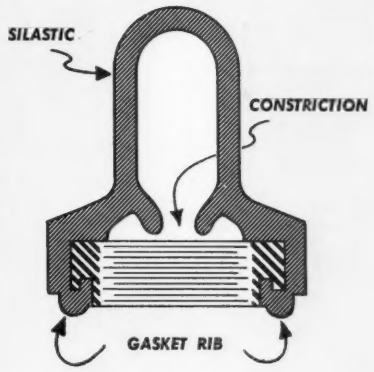
And availability in a wide range of carefully controlled viscosities reduces manufacturing costs. Liberal tolerances on the mating cylinders are compensated for by the simple selection of the fluid viscosity required to maintain an optimum damping force.

Furthermore, cost of the silicone fluid is almost negligible because the stability of Dow Corning 200 Fluid is so great that Dictaphone's engineers were able to design an effective damping device so small that the fluid is injected with a hypodermic needle.

Another recent application for Dow Corning 200 Fluid as a damping medium is in an automatic, electronic check-weight scale. Designed to weigh up to 120 packages a minute, the speed and accuracy of the scale is maintained by using a silicone fluid in the dashpot.

Organic fluids originally used as damping media thickened on cold mornings and reduced weighing speed. They thinned out in hot weather or after operating in the heat generated by the electronic components, and reduced the accuracy of the scale. These problems inherent in any fluid damping device where consistent performance is important were eliminated by using Dow Corning 200 Fluid. *No. 32*





Silastic* Boots Seal Toggle Switches at −80 to 500 F; Have 50 Times MIL Specification Flex Life at −67 F

You can seal a low temperature toggle switch by clamping a small Silastic O-ring between the metal parts. But that involves a multiple part assembly and does not provide insulation in case of short circuits.

That's why there has been so much interest in the Hexseal No. 1030, a new design developed by the Automatic & Precision Manufacturing Company of Yonkers, New York. In this unit the entire toggle is enclosed in a Silastic boot that is molded to the fastening nut.

Chemically bonded to a nickel-plated brass nut and serving both as a seal and locknut, the one-piece Hexseal can be easily and rapidly fastened down by hand. An integral rib at the base acts as a gasket when the Hexseal is secured, seating firmly against any panel surface, regardless of finish.

To determine flex resistance, the boot was subjected to 50,000 cycles at −67 F, or over 50 times the Military Specification (MIL-B-5423), without failing. It also withstood 100,000 cycles at room temperature; or 10 times the specification for the switch itself.

To make a good product even better, an inner constriction is molded in the throat of the boot. Should the tip become damaged, dirt and moisture are still excluded and pressure is still maintained. One potential user tested this feature by cutting off the tips. After thorough testing, they awarded contractual approval of the boots.

These Silastic toggle switch boots are already spreading from military to industrial applications. Originally specified for walkie-talkies, reflector buoys and bomb sights, they are now being used on industrial autoclaves and domestic butter churns.

In addition to the excellent low temperature flexibility demonstrated in the Hexseal application, Silastic 50 also gives excellent service in high temperature applications. Its dielectric properties make it a practical wire covering and cable coating for many electrical applications. With the exception of compression set, Silastic 50 meets all the requirements of SAE-ASTM Specification TA 505. It is a good, all purpose stock for making molded parts, tubing, gaskets, seals and belts that must remain serviceable over a wide range of temperatures.

Flex life of Silastic 50 at high temperatures is indicated in Table I. Failure to take a 180° bend over a ⅜ inch mandrel without breaking was taken as the end point in these flex life tests. At temperatures which caused organic rubber to fail in 8 to 96 hours, Silastic withstood 1344 to 6384 hours of exposure without failing the flex tests.

Using hardness as another measure of flexibility, samples of Silastic 50 kept

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(*continued pg. 2*)

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For copies of any of the publications reviewed in this column or for data relating to any of the articles printed in this issue of the Dow Corning Silicone News, simply circle the corresponding reference number on the coupon below.

"Silicone Release Agents for the Plastics Industry" describes various silicone mold lubricants, methods of application and concentrations used in compression, transfer or injection molding and in extruding, sheeting, rolling or forming of plastic parts. *No. 33*

•

The "Properties of Dow Corning Electrical Insulating Varnishes and Resins" are now compiled in a handy reference sheet. Typical applications and data on dielectric properties, viscosities, thinners and drying times simplify the preliminary selection of resins and varnishes for specific applications in the electrical industry. *No. 34*

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"Silicone Finishes for High Temperature Applications". This reprint of an article that appeared in FINISH magazine describes the properties and applications of various types of silicone resins used in formulating heat resistant paints with 10 to 50 times the life of the best organic finishes. *No. 35*

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Silicone-based water repellent finishes for above grade masonry walls repel water and water borne stains; virtually eliminate efflorescence and spalling without plugging the pores or changing the color or texture of masonry surfaces. Easy and inexpensive to apply, such silicone treatments remain effective for many years. Over 60 formulators of masonry water repellents made with Dow Corning silicones, are listed in our current "Sources of Supply". *No. 36*

•

"Silicones in Plant Auxiliaries" is the title of a significant article that appeared in the November 15th issue of ELECTRICAL WORLD. It tells how Consolidated Edison is using silicone (Class H) insulation to increase the life and reliability of motors and transformers. Solid proof of the performance of silicone insulation are orders placed since 1945 for over 106,000 hp in Class H motors rated from 200 to 2500 hp for station auxiliary power drives. *No. 37*

•

"Shoe Saver" is a new Dow Corning silicone product recently introduced for industrial use through Safety Supply Houses. Easy to apply and economical to use, it keeps leather shoes, gloves and oil guards soft and flexible, preserves stitching, increases resistance to abrasion and heat. "Shoe Saver" lets air in; keeps water, oil and various chemicals from penetrating the leather. AVAILABLE TO INDUSTRY THROUGH SAFETY SUPPLY HOUSES. *No. 38*

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New Silicone Resin Speeds Production of Laminates with 20,000 psi Flex Strength after 200 Hours at 500 F

Silicone-glass panel boards, tubes and structural parts with flexural strengths in the range of 50,000 psi at room temperature, and 12,000 to 20,000 psi at 500 F can now be laminated at low pressures and cured in a relatively short time at 480 F or cured in service.

Such laminates made with Dow Corning 2106 retain high physical strength even after aging at high temperatures. They are also water repellent, resistant to oxidation and to attack by many inorganic reagents. Inorganic laminates bonded with Dow Corning 2106 meet the requirements of Class H insulation.

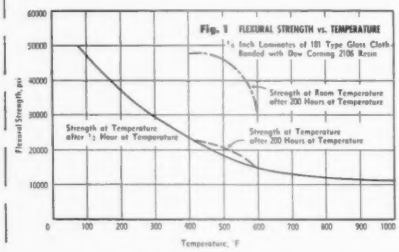
Fig. 1 FLEXURAL STRENGTH vs. TEMPERATURE
⅛ Inch Laminates of 181 Type Glass Cloth Bonded with Dow Corning 2106 Resin
Strength at Room Temperature after 200 Hours at Temperature
Strength at Temperature after ½ Hour at Temperature
Strength at Temperature after 200 Hours at Temperature
Flexural Strength, psi
Temperature, °F

Typical ⅛ inch laminates of 181 type glass cloth bonded with 2106 and cured for 48 hours at 500 F, have an initial flexural strength of 50,000 psi. As shown in Figure 1, flexural strength measured at room temperature is in the range of 40,000 to 50,000 psi after 200 hours of aging at temperatures up to 500 F. Flexural strengths measured at 100 to 1000 F after conditioning for ½ hour at the test temperature gradually decrease from 50,000 to 11,000 psi with increasing temperature. At temperatures from 100 to 500 F and after aging for 200 hours at test temperature, flexural strength is more than 20,000 psi.

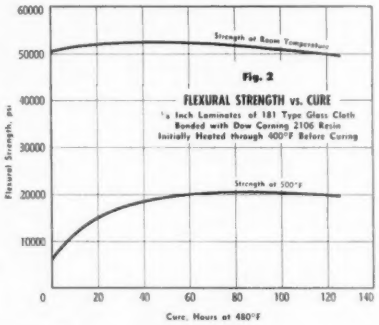
Fig. 2
FLEXURAL STRENGTH vs. CURE
⅛ Inch Laminates of 181 Type Glass Cloth Bonded with Dow Corning 2106 Resin Initially Heated through 400°F Before Curing
Strength at Room Temperature
Strength at 500°F
Flexural Strength, psi
Cure, Hours at 480°F

Even before curing, such laminates have a flexural strength of 50,000 psi at room temperature, as shown in Figure 2. Flexural strengths at 500 F are: 12,000 to 15,000 psi after curing 6-12 hours at 480 F; 14,000 to 18,000 psi after curing 24 hours; 18,000 to 20,000 psi after 48 hours at 480 F. These data indicate that laminates made with Dow Corning 2106 may be cured in service. *No. 39*

SILASTIC *continued*

TABLE I RESISTANCE TO HEAT AGING

Temp	Hours	Flex Life		Durometer, Shore A	
		Silastic	Organic	Silastic	Organic
300 F	0	OK	OK	54	61
	96	OK	Failed	57	
	168	OK		59	
	1344	OK		64	
	6384	OK		65	
392 F	0	OK	OK	54	61
	19	OK	Failed	54	
	168	OK		55	
	1344	OK		62	
	6384	OK		68	
480 F	0	OK	OK	54	61
	8	OK	Failed	54	
	168	OK		60	
	1344	OK		70	

their initial room temperature hardness of 56 at temperatures up to 480 F; increased to 60 at —67 F for a total change of only 4 points over a span of 547 Fahrenheit degrees.

After 70 hours immersion in water at 212 F, Silastic 50 showed only 4% increase in volume, 4 points decrease in hardness, no change in elongation, and 11% loss in tensile strength.

Silastic 50 can be blended with Silastic 80 to make parts with any hardness between 50 and 80. It can be given almost any color by adding heat-stable pigments. *No. 40*

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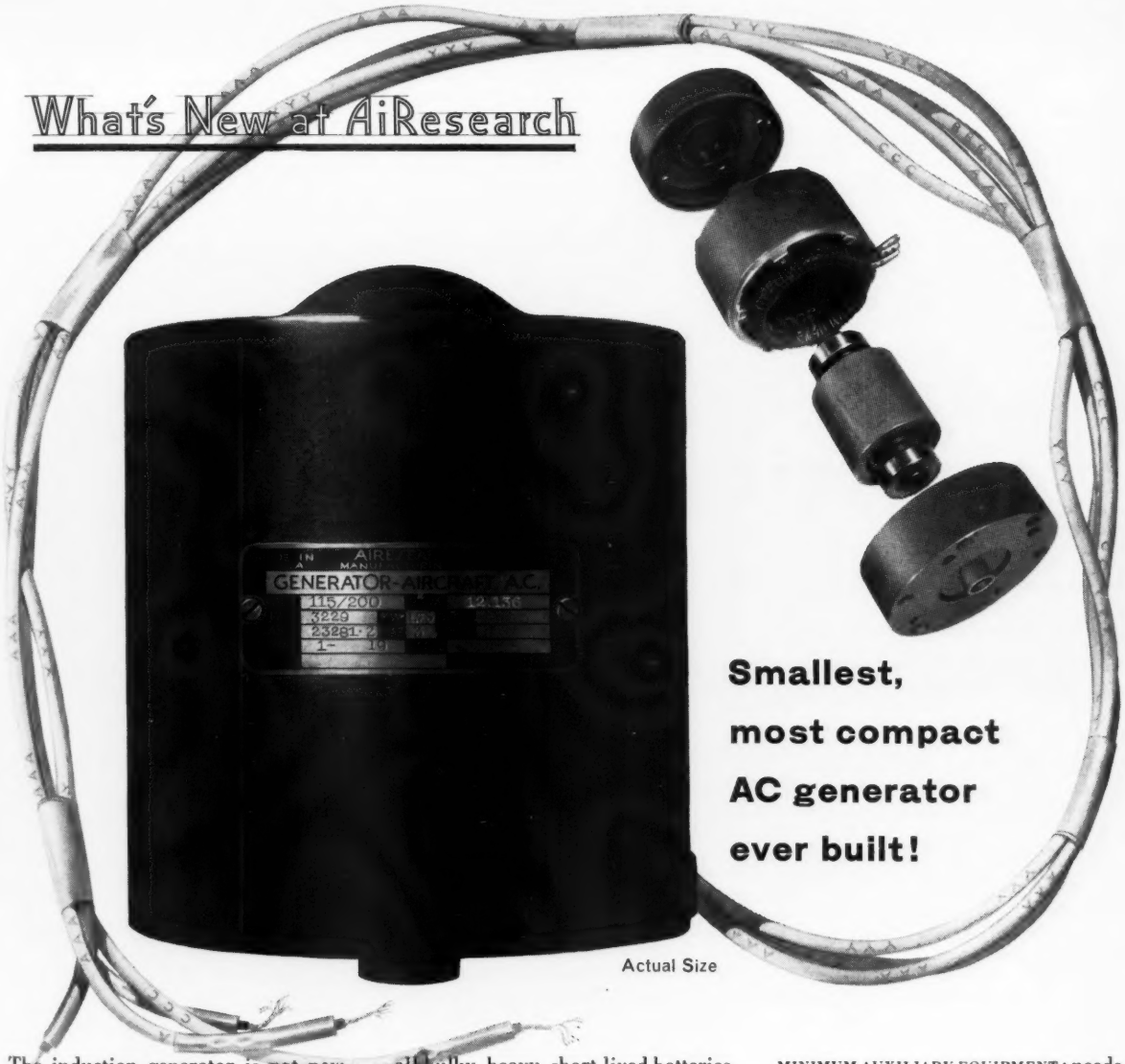

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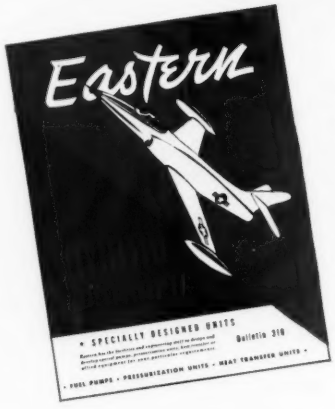

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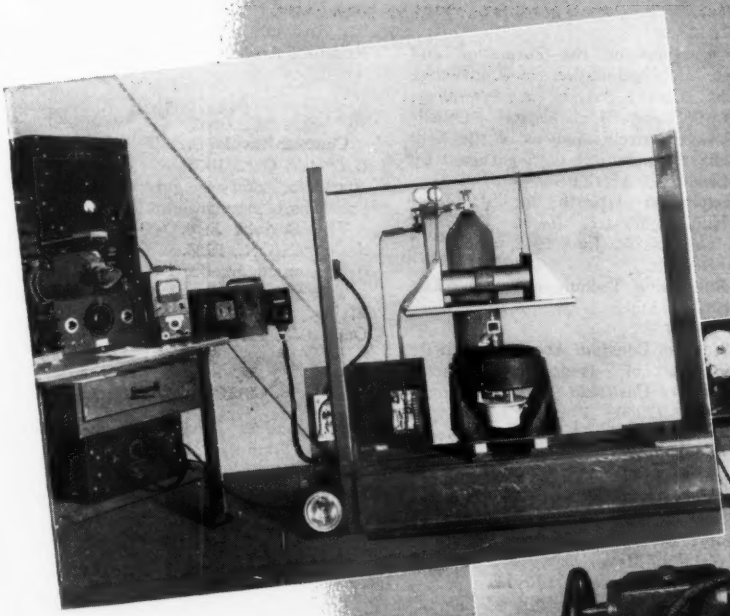

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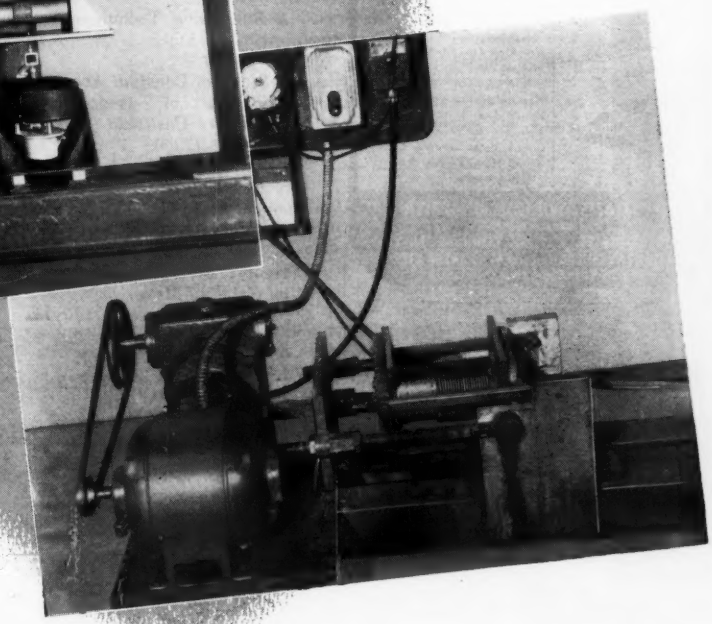

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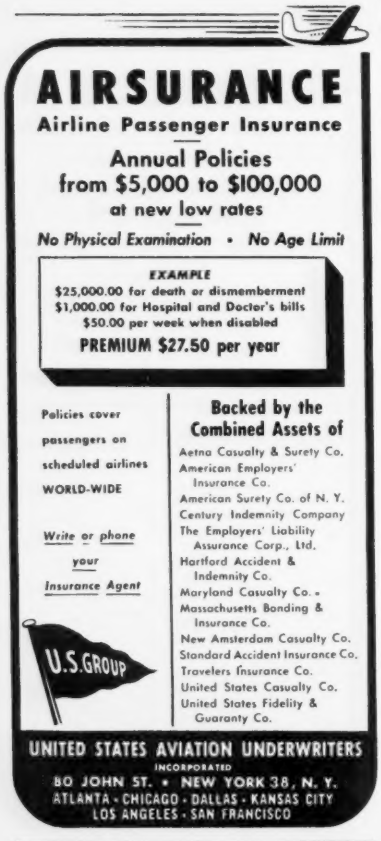
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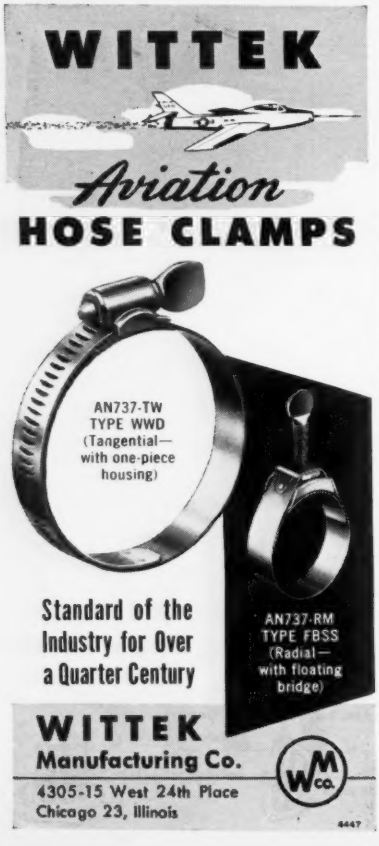

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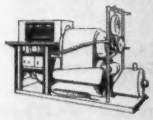

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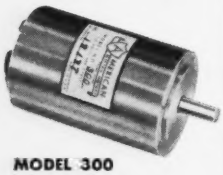

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MODEL 182A
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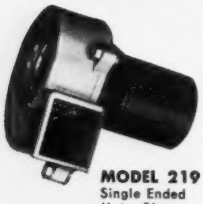

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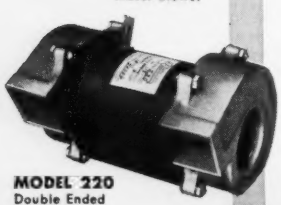

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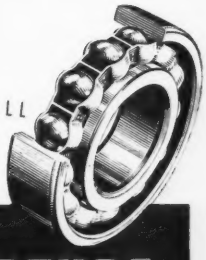

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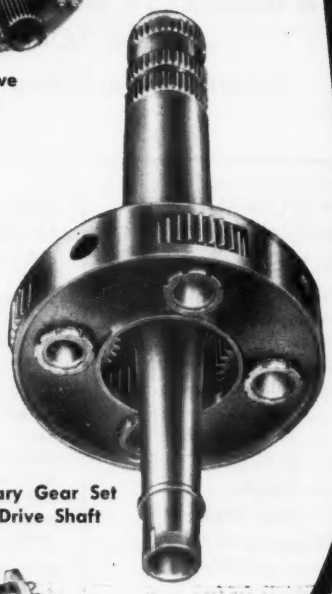

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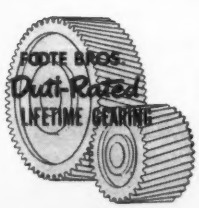

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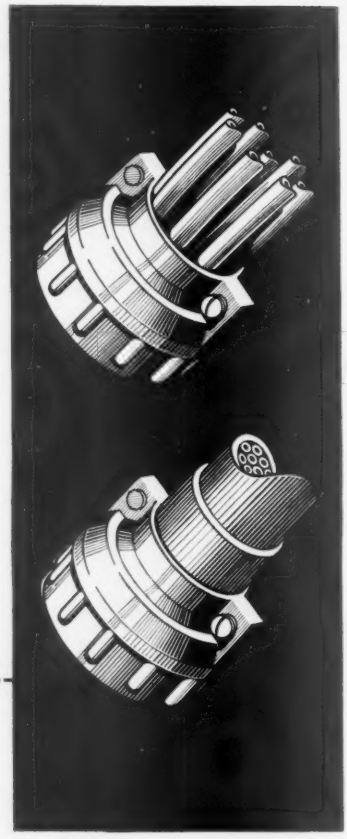

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Plastic Collapse of Thin Rings. Chintsun Hwang. *J. Aero. Sci.*, Dec., 1953, p. 819. 14 refs. For the case of collapse under concentrated forces that are symmetrical to the major axis.

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Buckling of a Right-Angled Isosceles Triangular Plate in Combined Compression and Shear. (Perpendicular Edges Clamped, Hypotenuse Simply Supported.) W. H. Wittrick. *Australia, ARL Rep. SM. 211*, June, 1953. 15 pp.

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De Experimentele Bepaling van de Meedragende Breedte van Valkke Platen in het Elastische en het Plastische Gebied (The Experimental Determination of the Effective Width of Flat Plates in the Elastic and Plastic Range). J. F. Besseling. *Netherlands, NLL Rep. S.414*, Feb., 1953. 92 pp. 26 refs. In Dutch.

The Load Carrying Capacities of Circular Plates. H. G. Hopkins and W. Prager. *J. Mech. & Phys. Solids*, Oct., 1953, p. 1. 14 refs. For the case of perfectly plastic materials obeying the yield condition of Tresca and the associated flow rule.

Neutral Holes in Plane Sheet-Reinforced Holes Which are Elastically Equivalent to the Uncut Sheet. E. H. Mansfield. *Quart. J. Mech. & Appl. Math.*, Sept., 1953, p. 370.

Some Extensions of "Rayleigh's Principle." R. V. Southwell. *Quart. J. Mech. & Appl. Math.*, Sept., 1953, p. 257. Application to the class of problems concerned with the stability of flat plates sustaining edge-thrusts, with the eigenvalues defining the critical intensities of the loading.

Wings

Analysis of Experiments on Swept Wing Structures. D. Howe. *Coll. of Aeronautics, Cranfield, Rep. 65*, May, 1953. 46 pp. 18 refs.

A Procurement Standard for a Metal-Sandwich Type Wing Tip. Harold H. Rosenbaum. *ASTM Bul.*, Sept., 1953, p. 38. Convair structural specification, including design and manufacturing phases.

A Simplified Theory of Swept Wing Deformation. A. H. Hall. *Canada, NAE Rep. 19*, 1953. 21 pp. Theoretical and experimental structural analysis.

Structural Efficiency of Multi-Web Wings. J. Solvey. *Australia, ARL Rep. SM 212.* 74 pp. Numerical investigation of relative criteria.

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Design Charts for Symmetric Regenerators. A. M. Peiser and J. Lehner. *Ind. & Eng. Chem.*, Oct., 1953, p. 2166.

Effective Thermal Conductivities of Magnesium Oxide, Stainless Steel, and Uranium Oxide Powders in Various Gases. C. S. Eian and R. G. Deissler. *U.S., NACA RM E53G03*, Oct. 29, 1953. 18 pp.

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Thermo-electricity at Low Temperatures. I—The "Ideal" Metals: Sodium, Potassium, Copper. D. K. C. MacDonald and W. B. Pearson. *Proc. Royal Soc. (London), Ser. A*, Sept. 22, 1953, p. 373. 33 refs. Theoretical and experimental studies of thermal and other properties.

Trasformazioni Adiabatiche di Ampiezza Finita (Adiabatic Transformations of Finite Amplitude). Piero Giorgia Bordoni. *La Ricerca Sci.*, Sept., 1953, p. 1569. In Italian. Evaluation of temperature changes of adiabatic transformations by means of a thermodynamic potential for homogeneous isotropic solids; analysis of adiabatic elasticity problems.

Wind Tunnels & Research Facilities

Aerofoil Models; The Manufacture and Inspection of Two-Dimensional and Three-Dimensional Types. R. S. Marriner. *Aircraft Prod.*, Oct., 1953, p. 398. For use in wind tunnels.

Aeronautical Engineering. V. M. Ganzer. *Trend in Eng.*, Oct., 1953, p. 9. 69 refs. Review of research activities in the U. of Wash. Aero. Eng. Dept., with a bibliography covering 1948–1953.

The Improvement in Pressure Recovery in Supersonic Wind Tunnels. H. Eggink. *Gt. Brit., ARC R&M 2703* (May, 1949), 1953. 18 pp. BIS, New York $1.15.

Processing of Two-Dimensional Patterns by Scanning Techniques. L. S. G. Kovasznay and H. M. Joseph. *Science*, Oct. 23, 1953, p. 475. Use of a "flying-spot" scanner and a "slave" oscilloscope monitor for research investigations.

Relationship of Research to Aircraft Operations. William Littlewood, Moderator, and others. *Skyways*, Nov., 1953, p. 20. Flight Operations Round Table discussion.

Fourth International Aeronautical Conference

(*Continued from page 22*)

stitution's auditorium was filled to capacity, and even standing room in the balcony was utilized.

Other Social Events

Immediately following the Wright Lecture, a formal reception and buffet supper was held by the officers and council of The Royal Aeronautical Society at 4 Hamilton Place. This marked the first official social event of the Conference and served to bring all of the delegates together for a congenial evening preceding the technical sessions.

A large tent had been erected on the terrace of the Society's building, the library had been cleared for dancing, and the council room and every available office had been converted into service rooms for refreshments and the buffets. Thus arranged, and attractively decorated with floral bouquets, the building was difficult to recognize as the headquarters of a staid, old engineering society. The fact that the party continued until the late hours is a further tribute to the hospitality of the hosts and the tireless efforts of the RAeS staff.

On Tuesday evening, September 15, Her Majesty's Government welcomed the Conference delegates to a reception at Lancaster House, in St. James's. Here, the guests were received by A. R. W. Low, Parliamentary Secretary to the Ministry of Supply.

The Council of The Royal Aeronautical Society gave a dinner at the headquarters building on Wednesday evening, September 16, for members of the Institute's Council. This informal and pleasant meeting gave ample opportunity for the discussion of matters of importance to both societies and resulted in the decision to hold the Fifth International Aeronautical Conference the latter part of June, 1955, on the West Coast of the U.S.A.

Thursday, September 17, marked the official wind-up of both the business and social events of the Fourth Conference. A formal dinner-dance in the ballroom of the Dorchester Hotel provided a fitting climax to a meeting that had been most successful throughout.

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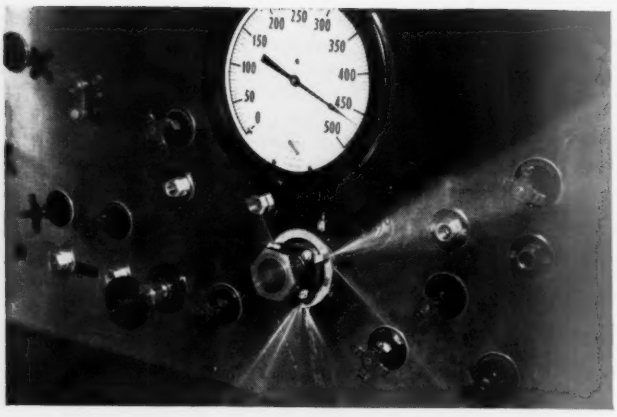

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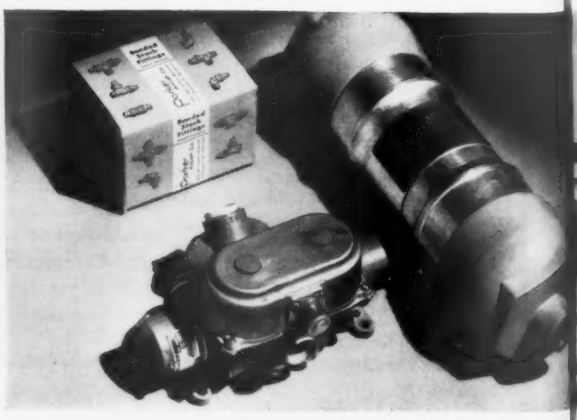

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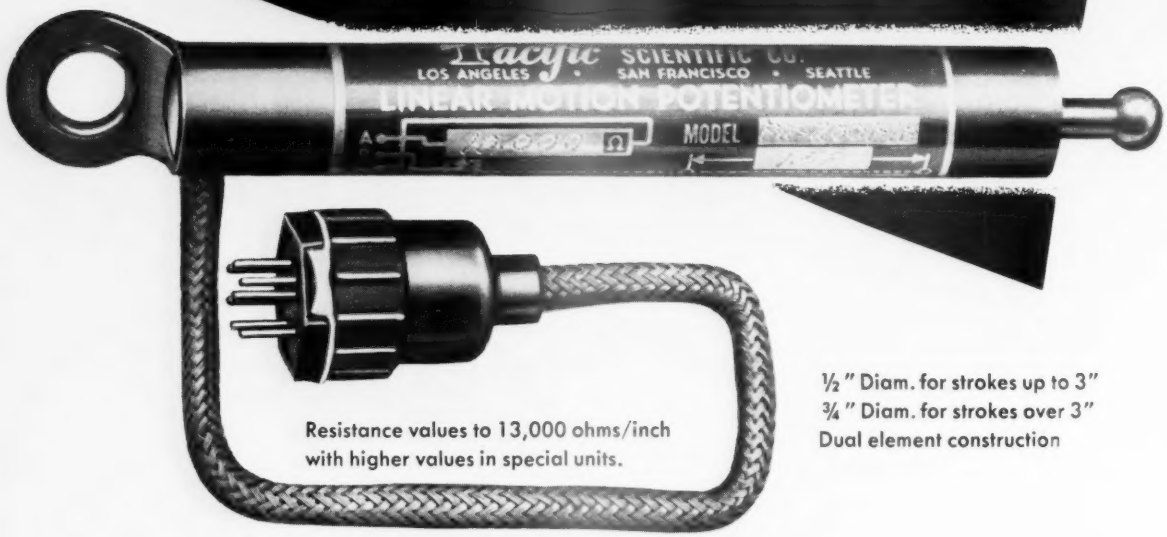

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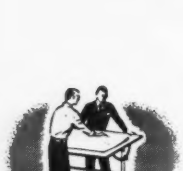

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Aeronautical Reviews — BOOKS

Book Notes

AIRPLANE DESIGN

Aeroplanes and Aero-Engines. From the Original Cutaway Drawings by J. H. Clark, Leslie Creswell, Roy Cross, Charles Hurford, and Theo Page. 3rd Ed. Reprinted from *The Aeroplane*. London, Temple Press Limited, 1953. 26 pp. 4s. 6d.

Selected drawings of 17 airplanes, one helicopter, and seven power plants, ranging from the comparatively simple four-cylinder reciprocating engine to the axial-flow turbine for civil purposes.

ELECTRONICS

Fields and Waves in Modern Radio. Simon Ramo and John R. Whinnery. 2nd Ed. New York, John Wiley & Sons, Inc., 1953. 576 pp., diagrs., figs. $8.75.

In this edition much new material has been added, including a new chapter on microwave networks; simple examples in the chapters on static fields; the useful Smith chart in the simple transmission line treatment; several new aspects of propagating waves, such as the principle of duality and slow-wave circuits; and new features in the chapter on radiation, such as discussions of horns, slot antennas, receiving antennas, and more on arrays.

INSTRUMENTS

Temperature Measurement in Engineering. Vol. 1. H. Dean Baker, E. A. Ryder, and N. H. Baker. New York, John Wiley & Sons, Inc., 1953. 179 pp., diagrs., figs. $3.75.

The object in this two-volume work is to provide in convenient nonmathematical form the information necessary to the engineer who wishes to measure temperature. The approach is to provide a comprehensive list of possible techniques, the methods of analysis, a survey of previous designs, the specific information needed for feasibility of execution, and a well-developed procedure of general applicability. References in the text are made to the literature cited at the ends of chapters. The types of conditions encountered are classified on a physical basis: as interior points in solids, liquids, gases, flames, etc., rather than as the problems of specific industries or as related to various types of instrumentation.

H. Dean Baker is Professor of Mechanical Engineering, Columbia University, and Consultant, Pratt & Whitney Aircraft Division, United Aircraft Corporation. E. A. Ryder is Consulting Engineer, Pratt & Whitney Aircraft Division, United Aircraft Corporation. N. H. Baker is Research Assistant in the Department of Mechanical Engineering, Columbia University.

Contents: (1) Temperature. (2) Methods for Measuring Temperature. (3) Precision Requirements. (4) Conditions Affecting Temperature Measurement. (5) The Thermocouple Thermometer—Circuits. (6) Indicating Instruments. (7) Design Calculation Techniques. (8) Installation Design Types. (9) Drilling Technique. (10) Special Materials: Protective Coatings, Heat- and Corrosion-Resistant Metals, Plastics, Refractories, and Cements. (11) Cemented Installation Designs. (12) Temperature Gradient Installation Designs. (13) Conclusion to Volume I. Name Index. Subject Index.

MATHEMATICS

Higher Transcendental Functions. Vol. 2. Based, in Part, on Notes left by Harry Bateman, Late Professor of Mathematics, Theoretical Physics, and Aeronautics at the California Institute of Technology, and Compiled by the Staff of the Bateman Manuscript Project. New York, McGraw-Hill Book Company, Inc., 1953. 396 pp., illus. $7.50.

The present second volume contains chapters on Bessel functions and other particularly confluent hypergeometric functions, on orthogonal polynomials and related matters, and on elliptic functions and integrals. The method of compilation was similar to that of the first volume, and chapters are numbered consecutively from that. A list of references is given at the end of each chapter.

Contents: Chapter 7, Bessel Functions. Chapter 8, Functions of the Parabolic Cylinder and of the Paraboloid of Revolution. Chapter 9, The Incomplete Gamma Functions and Related Functions. Chapter 10, Orthogonal Polynomials. Chapter 11, Spherical and Hyperspherical Harmonic Polynomials. Chapter 12, Orthogonal Polynomials in Several Variables. Chapter 13, Elliptic Functions and Integrals. Subject Index. Index of Notations.

Cambridge Elementary Statistical Tables. D. V. Lindley and J. C. P. Miller. New York, Cambridge University Press, 1953. 35 pp. $1.00.

This set of tables is concerned only with the more common and more familiar and elementary of the many statistical functions and tests of significance now available.

Contents: Preface. Tables: (1) The Normal Distribution Function, The Normal Frequency Function. (2) Percentage Points of the Normal Distribution. (3) Percentage Points of the t-Distribution. (4) Transformation of the Correlation Coefficient. (5) Percentage Points of the χ^2-Distribution. (6) Conversion of Range to Standard Distribution. (7) Percentage Points of the F-Distribution. (8) Random Sampling Numbers. (9) Squares, Square Roots, Reciprocals, Reciprocal Square Roots, Logarithms, Antilogarithms, Inverse Circular and Hyperbolic Root-Sines. (10) Logarithms of Factorials. Proportional Parts.

STRUCTURES

Applied Elasticity. Chi-Teh Wang. New York, McGraw-Hill Book Company, Inc., 1953. 357 pp., diagrs., figs. $8.00.

This book is an outgrowth of courses in the theory of elasticity given by the author for graduate engineering students at New York University, where he is Professor of Aeronautical Engineering. In preparing the lecture notes, the author had two objectives in mind: first, to provide the student with the necessary fundamental knowledge of the theory so that he will be able to formulate any problem occurring in the classical theory of elasticity; and, second, to acquaint him with the most useful analytical and numerical methods so that, after the problem is formulated, the student will be able to solve it by one of these methods. In presenting the material, the mathematics is kept at a level that does not presume a thorough background in advanced calculus. Whenever higher mathematics is involved, it is derived where it is first encountered. The book is intended mainly for engineers, and the attempt is thus made to emphasize the physical meanings of the notations and mathematical relationships occurring in the subject. Discussed in detail are several of the most powerful numerical methods that usually yield an approximate solution with sufficient accuracy for engineering applications. Problems for solution by students and footnote references are given.

Contents: (1) Analysis of Stress. (2) Analysis of Strain. (3) Stress-Strain Relations and the General Equations of Elasticity. (4) Plane-Stress and Plane-Strain Problems. (5) Torsion of Various-Shaped Bars. (6) Finite-Difference Approximations and the Relaxation Method. (7) Energy Principles and Variational Methods. (8) Solution by Means of Complex Variables. (9) Bending and Compression of Bars, Elastic Stability. (10) Numerical Methods in the Determination of Buckling Loads. (11) Bending and Buckling of Thin Plates. (12) Theory of Thin Shells and Curved Plates. Index.

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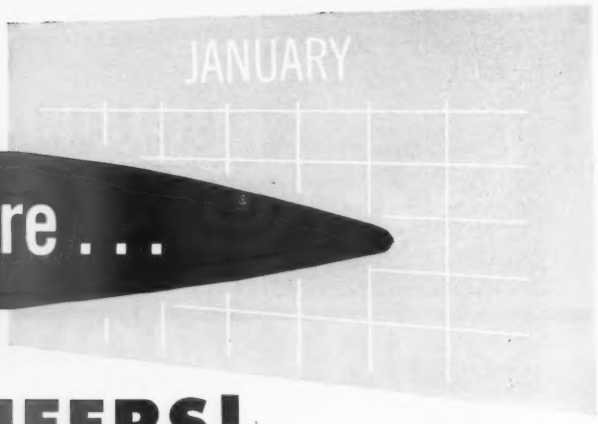

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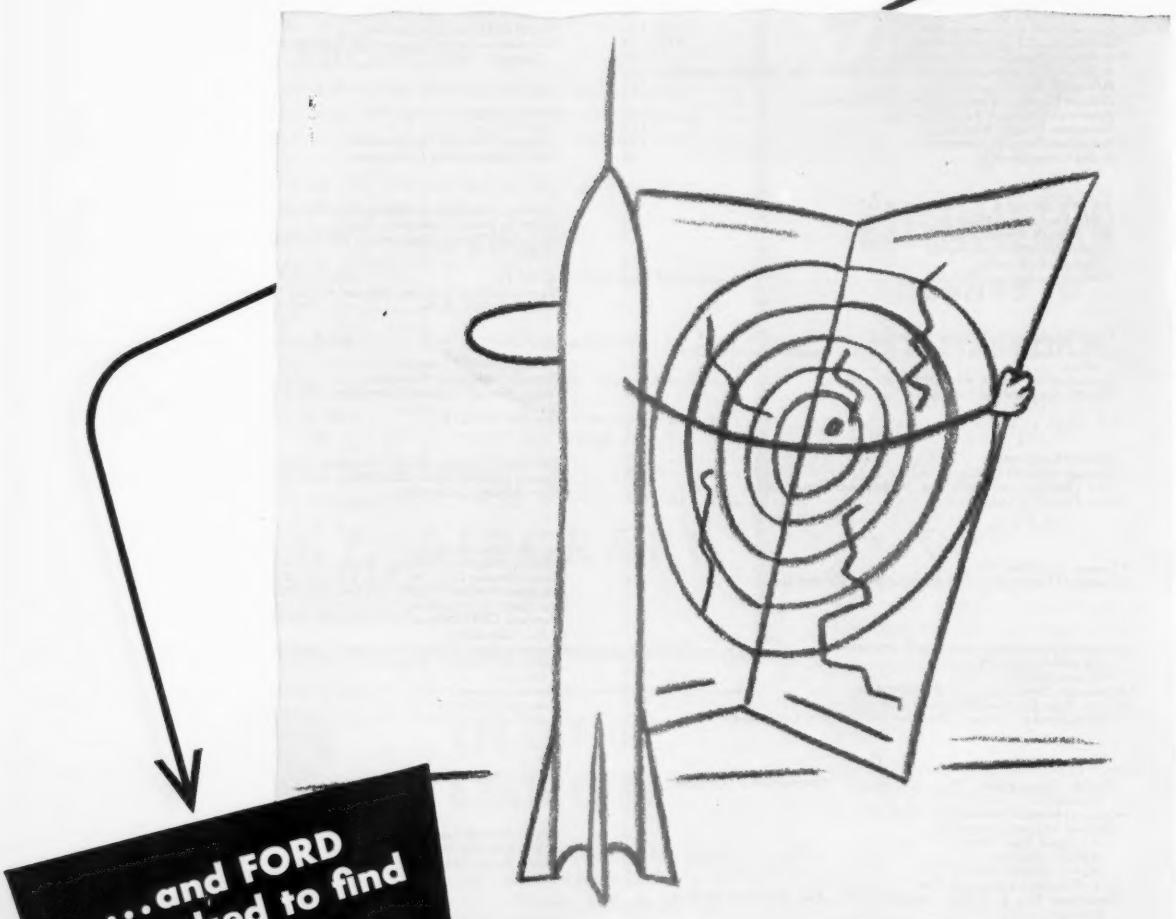

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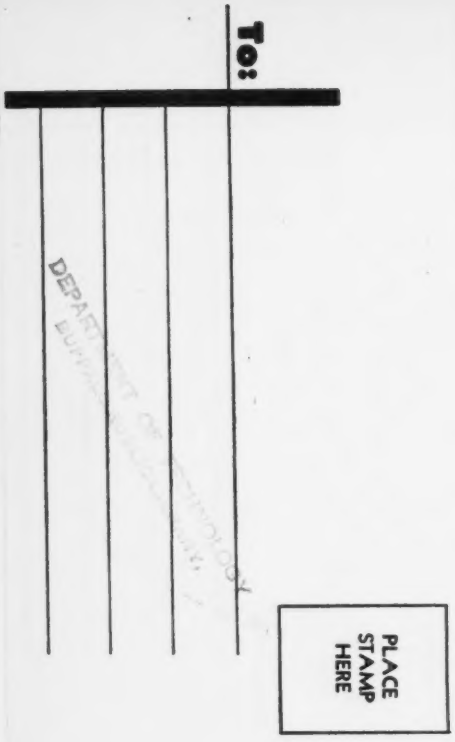

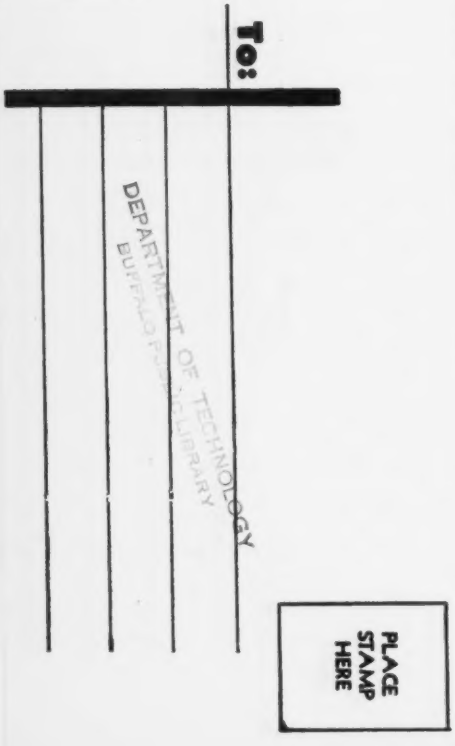

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